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1881	contained	28	different	adv'ts.	1888	cont'ined	175	different adv'ts.
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Special Notice.—*The Western office of The Electrical World, which has for several years been located at 465 The Rookery, Chicago, will hereafter be found at 636 Monadnock Block, where larger, more convenient and more cheerful quarters have been obtained in the new wing known as "Section C." This addition to the original building is really not yet entirely completed in its internal arrangements. For instance, the elevator which is to run in front of The Electrical World's office will not be in commission for several weeks, but in the meantime one of the other elevators, of which there are a dozen or so, can be taken to the ninth floor. It is to be hoped that the Chicago friends of The Electrical World and those visiting the World's Fair city will make a point of visiting the office, where they can always rely upon a cordial welcome.*

VOL. XXI. NEW YORK, MAY 6, 1893. NO. 18.

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Fixture Cut-Outs. WHILE electric light fittings in general have undergone an improvement within a recent period amounting to almost a revolution, there is still vast room for improvement in fixture cut-outs. For fixtures with large canopies the present forms are passably adapted, yet a fused hole in a canopy is no uncommon occurrence and assurance is only rendered certain by wrapping with tape each time a new fuse is required. For small fixtures and especially side brackets the want of a practicable cut-out is particularly pressing. The use of "bugs" with the latter, often shoved behind the plastering, is barbarous, and it is surprising that their extended use has been permitted by electrical insurance inspectors. In the early days of electric lighting attempts were made to supply the deficiency, but of late years there has been apparently little or no advance. It would seem that this is a field for the inventor, but the probability of a small reward has perhaps deterred the efforts that otherwise would have been made.

The Feeder and Main Patent. AN examination of the full text of Judge Green's opinion in the case of the feeder and main patent shows that the point at issue related merely to the use of feeders in connection with incandescent lamp circuits. The view taken by the court was, briefly, that the delicate nature of incandescent lamps absolutely required close regulation of the voltage; that this regulation could not be effected by the customer nor at the station in a general system; that the division of the circuits into feeders and mains, in the opinion of the court, practically localized the drop to the former, thereby insuring regularity in the voltage at the lamps. This method of obviating a difficulty that the court considered hitherto insuperable constituted, in its opinion, an invention, and Mr. Edison was awarded priority. While the patent in litigation may or may not be broad enough in its application to cover motor and trolley circuits with feeders, as only the specific claims relating to incandescent lamp circuits were actually passed upon in this trial, it naturally follows that the decision affects these claims alone. It is understood that the case will be carried to a higher court.

Candle Power of Arc Lights. A NUMBER of enterprising gentlemen connected with the arc light industry have petitioned that the question of the proper definition of the candle power of arc lamps be considered by the coming Electrical Congress. This is a matter of no small importance, and one at present in a decidedly unsatisfactory state. It is true that some companies specify in their proposals the ampères corresponding to the rated capacity in lamps of their dynamos, but this is not always the case, and besides furnishes no assurance that in actual use the owners will supply the proper current to the lamps of their customers. The only practicable criterion is that proposed, which is that the candle power shall be defined in terms of the watts delivered to the lamps. With such a definition established, municipal authorities will be enabled to indirectly check the candle power of their lamps by leading a loop of each circuit, where possible, into a neighboring public building and placing an ammeter in circuit; by occasionally checking, in addition, the voltage of some of the lamps, which will remain approximately constant with the same kind of carbons, they will thus have the means of knowing whether they are supplied with the light contracted for, and the cause of much friction will be removed.

The World's Fair. The opening of the World's Columbian Exposition at Chicago this week is the commencement of one of those huge periodical inventories of human progress when mankind pauses for a moment to gaze with wonder on its own achievements. In no department of the Exposition will the lover of his kind feel greater pride, not unmixed with awe, than when he contemplates the tremendous advances in electrical science and art as illustrated by the exhibits in this department. This is the first opportunity that America has had to inspect collectively the marvellous electrical creations that have had their origin and development almost entirely since the Centennial Exposition, the Philadelphia Electrical Exhibition of 1884 being of relatively minor note. As foreshadowed in the accounts that have appeared in our columns, every branch of electricity will be adequately represented, and that a great impetus will be given to further developments can be safely predicted in view of the great stimulation the American inventive and business faculties will experience. As an example, the intra-mural railway we describe and illustrate in this issue will furnish an instructive object lesson in this field of traction that will cause electricity to be more seriously considered as a successor to steam on our elevated structures throughout the country. If through this New York shall be relieved of the smoke and cinders that at present so sorely afflict her, she may feel amply compensated for the loss of the magnificent Exhibition that has now started on its course.

The Trolley Patents. THE recently issued and apparently fundamental trolley patents will undoubtedly result in another great legal battle, but until the case is finally passed upon by the higher courts there can be little or no certainty as to their value. It has now come to be pretty well understood that a patent merely gives an inventor a status in the courts, with perhaps an advantage due to the favorable verdict of the Patent Office on his claims, and whether this state of affairs is deplorable or not is a question. One incontestable advantage is that the evidence for and against patentability, and the consequent establishment of a monopoly, is thus enabled to be considered in the courts in an exhaustive and learned manner that cannot be at all approached by the Patent Office for various reasons. In the present instance it seems probable that one or both of the following points will be reviewed in court: Were the fundamental mechanical principles involved in the trolley patents in question anticipated in the numerous patents previously issued for trolleys intended to be used in the operation of telegraph instruments on steam railway cars? Can a contact device designed for use with telegraph instruments and therefore small currents be considered an invention if applied in connection with the motor of an electric railway car and consequently large currents? Independently of this presumptive issue there will probably be others based on electric railway trolley patents, so that at present there is no reason for disquietude on the part of alleged infringers.

Kennelly on Impedance. THE paper on impedance read before the last meeting of the American Institute of Electrical Engineers is the third very notable contribution Mr. Kennelly has made to electrical science through the same medium, the two previous ones being on inductance and on magnetic reluctance. In this paper is again displayed the admirable faculty of taking an involved and little understood subject, and by a remarkably lucid and non-mathematical treatment placing it within the grasp of the merest tyro in electricity. It is not too much to say that the working knowledge of impedance that even the beginner can easily derive from this paper could not otherwise be obtained at the present time than through a profound knowledge of mathematics and after an extended study of learned treatises and of papers difficult of access—in which besides the different parts of the subject would be found considered disconnectedly and aside from their practical bearing. Indeed even then the student would be at a disadvantage, as the treatment of currents not following the sinusoidal law and the discussion of drop in conductors are apparently entirely new, as well as, to a great extent, the extremely simple and complete method of determining the impedance of complex circuits involving resistance, inductance and capacity. While the paper is thus of notable value as a logical and simple exposition of a subject heretofore only disconnectedly treated, and then in an unusually involved manner, it is even more commendable for its practical deductions relating to the drop of voltage in alternating current conductors. In this respect Mr. Kennelly has made a practical contribution to electrical engineering that is only comparable in value to his similar treatment of the subject of the heating of conductors by electric currents, the results of which have been definitely adopted throughout the world as the data of practice. That the percentage of increase of drop in voltage due to alternating currents is so considerable will be a surprise to many, and hereafter, no doubt, carefully drawn specifications will require such conductors to be proportioned accordingly, in which case, fortunately, the data are at hand in practical shape in the tables accompanying the paper.

Reliability of Tests. THE aversion shown by many to reports of efficiency and other tests has a true foundation independent of a suspicion that the results have been "cooked" for interested purposes. In a test of even simple character a constant exercise of judgment is necessary, while nothing should be taken for granted in regard to the reliability of the instruments used. These remarks may seem trite, yet they are none the less important and their application is too often lost sight of. The former applies particularly where the conditions of a trial are variable or where a personal estimation of some point enters into the results. In engine trials it is usual to assume the indicator to be correct, yet recently a large number of indicators of a standard make was rejected because not one fulfilled the requirement of a maximum error of two and one-half per cent.; the error of a low pressure indicator may easily be eight per cent., and in any case the readings of an indicator cannot be true at every part of the scale. An example that recently came under the notice of the writer was in relation to the test of an electric light engine, which proved so unfavorable that the owner thought of replacing the engine by another. An examination of the data showed that the "expert" had taken the mean of two trials, one of 12 hours and another of only several hours' duration; while the former gave satisfactory results, the latter, through wrong estimation of the condition of the fire (or none at all), gave a result entirely too high. In another instance an "electrical engineer" lost his position because the data from his test of a dynamo gave an efficiency of over one hundred per cent., on account, it was subsequently discovered, of the instrument reading incorrectly; had the efficiency come within the limit it would probably have been accepted without reference to the instruments. In a certain manufacturing establishment the weekly report of the engineer regularly shows the consumption of refuse coal per horse power per hour to be between 1.5 and 1.6 pounds, the engine being of the compound condensing type. These examples may be extreme, but they belong to an important class whose effect tends to cast suspicion on tests generally; even an extended examination of published reports of tests by professional experts of a given type of engine will be found far from reassuring. In order that errors other than those of observation may be checked, all reports, to have serious consideration, should be accompanied by an exact and certified transcript of the original data sheet, on which there should be no corrections, even of supposed palpable errors, which may, in fact, be the means of a proper interpretation and estimation of the test,

The Opening of the World's Columbian Exposition.

An excellent resume of the electrical features of the World's Fair which appeared in a recent issue of the "New York Herald" calls attention to a point which is worthy of consideration, which is that it has been the aim of Chief Barrett and his assistants to demonstrate that electricity is not a "mysterious force," that it is not in its infancy, and that it is not a dangerous thing. On the other hand they are undertaking to prove that it is a quantity as certain as steam, quite as easily generated and far more easily controlled.

The source of power for operating the various electrical features, such as the intramural railway, electric fountains, large cranes, etc., comes from the plant in Machinery Hall, which was fully described in the last issue of The Electrical World. One feature of the installation is that no wires are to be allowed above ground, adequate subways having been provided for the entire system. The entire grounds and buildings will be most brilliantly illuminated by electric lights and the lighting of the Manufactures and Libreal Arts Building, which was illustrated and described in The Electrical World of March 18, 1893, is to be a feature of the Fair. Throughout the grounds at every possible point, not only on the buildings and fountains, but among the flowers and foliage, the incandescent lamp will play a prominent part and transform the scene into a veritable fairyland.

The exhibitors in every line have exhausted their resources in the preparation of booths and attractive displays of all kinds. One of the most striking of these will be the pavilion of the American Bell Telephone Company, shown in The Electrical World of April 29, which will contain models of more than 500 patents and a complete exhibit of the telephone in all its forms.

The incandescent lamp will come in for a large share of attention, and a very complete historical exhibit is expected, but the main part of this feature will be the General Electric Company's tower, of which a full page illustration was given in The Electrical World of April 8, 1893.

The dynamo and motor will be seen in all their various types from the earliest form to the immense 10,000-light machine of the Westinghouse Electrical Manufacturing Company, an illustration of which will be seen by reference to the last issue of The Electrical World. Apparatus for the transmission of power will be given special prominence. It is also stated that Prof. Thomson is also preparing some very interesting high potential experiments for which a current of 100,000 volts will be employed.

The Western Electric Company's exhibit bids fair to be of unusual interest, although it aims at quality, not quantity. The model theatre which forms a part of it will perhaps attract the most attention as various mountain, country and water scenes are to be produced by purely electrical effects. A very realistic lightning effect will also form a part of this company's exhibit.

Two great forging and welding companies, the Thomson Welding Company and the Electrical Forging Company, will have very attractive exhibits, some of the machines being capable of welding a bar of iron or steel of the thickness of six inches.

The exhibits of the telegraph companies, the Western Union and the Commercial Cable Company, aim to be historical rather than commercial, and embrace a model cable steamer including the apparatus for laying cables, and instruments for their testing. The Commercial Cable Company's pavilion will be one of the handsomest on the floor. The Western Union Company has gone to great expense to procure such interesting relics as the original Morse instrument, a model of the "Great Eastern," etc.

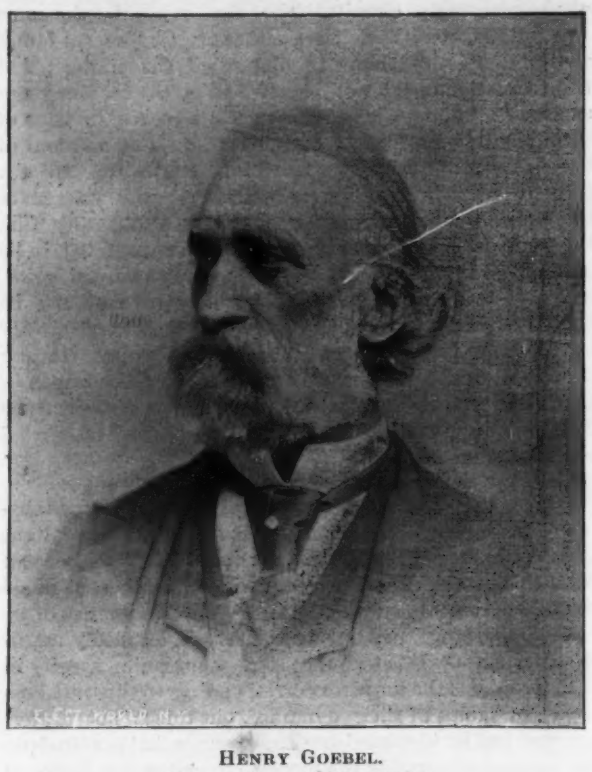
While the principal Edison exhibit is on the ground floor, perhaps the more interesting portion of it will be found at the south end of the gallery, and comprises such instruments as the phonograph, kinetograph, etc., which will undoubtedly prove a great source of attraction to the general public. One of the other novel features of the electrical exhibit will be Prof. Gray's telautograph, which has recently been placed on the market, and a very complete description of which will be found in The Electrical World of March 25, 1893.

Running over the various exhibits which are already on the grounds and taking into consideration those which are yet to be installed, but the general features of which have been made public, there seems to be little doubt but that the electrical department will form the most attractive faeture of the fair. While it is not in any sense complete at the time of the opening, work is progressing with wonderful rapidity, and a few weeks will see this section of the Exposition in a fairly finished state.

On Monday at eight minutes past noon, in the presence of 150,000 people, including the Duke of Veragua, members of the Cabinet, and many other distinguished personages, the President of the United States pressed the electric button which started the machinery and formally opened the Exposition. Instantly the great Allis engine in Machinery Hall began to revolve, the fountains threw up jets of water, the thunder of artillery came from the vessels on the lake, and bells and whistles all over the city joined in the universal celebration. While it did not rain, the weather was dismal, but this seemed to have no effect on the enthusiasm of those present. In addition to the address of the President, Director-General Davis delivered a discourse briefly presenting the history of the work and pointing out the great benefit to be derived from it.

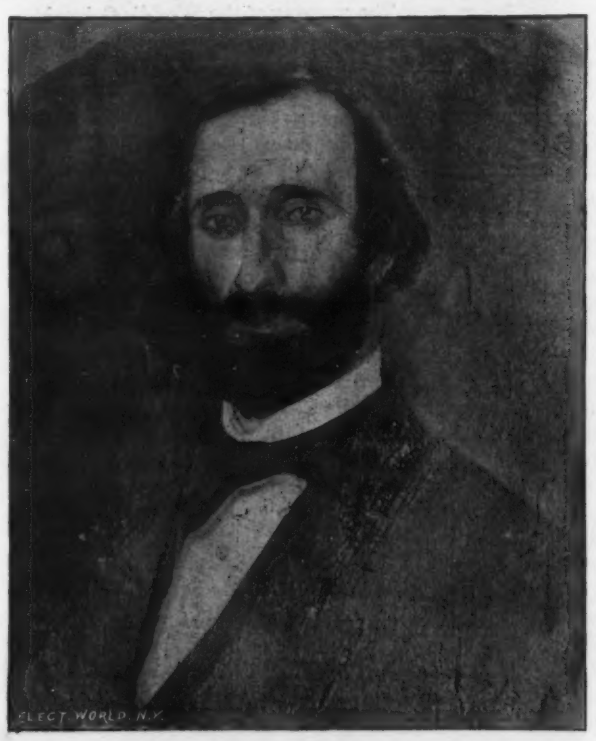
Henry Goebel.

The person who is perhaps the central figure of attraction in the electrical field just at this time, is Henry Goebel. The eyes of the electrical world are upon him, seeking to discover what manner of man he is, and the more exact nature and extent of his work in years gone by, the results of which have played so important a part



HENRY GOEBEL.
(From a Recent Photograph.)

in the recent incandescent lamp litigation. Few characters have risen from obscurity into such sudden prominence, and the general public looks forward to the careful sifting of the evidence by the court, and the separation of the wheat from the chaff, that the world may know how much or how little it is indebted to this interesting character for the origination and perfection of one of its most valuable inventions. That Henry Goebel is an imposter, pure and simple, none who have examined carefully into his remarkable history, or have come in contact personally with this frank, genial, honest-hearted old gentleman, would for a moment admit; that he anticipated Edison in the invention of the commercial incandescent



HENRY GOEBEL
(From an Oil Painting.)

lamp, and that to him in truth belongs the credit, is a question too broad to be decided without the most careful examination of his work, and the closest scrutiny of his claims—a task which the public is quite willing to commit to those whose duty it is to pass upon such matters.

Heinrich Goebel, or, as he is commonly known in this country, Henry Goebel, was born on the 20th of April, 1818, in the village of Springer, a small place not far from Hanover, Germany. His seventy-fifth birthday fell, therefore, the day before Judge Hallett handed down his decision at St. Louis. His father was engaged in various lines of business, but during the latter part of his life devoted most of his time to the manufacture of chocolate. Heinrich Goebel is the last survivor of the family, his own brother dying a few years ago, and several half-sisters having long since passed away.

He received a fair education in the branches commonly taught in the public schools in his native village, but never took very kindly to books. In fact, he stated in a recent conversation with a representative of The Electrical World, that going to school was the hardest task he ever undertook. He early developed the tastes of a mechanic, and a fondness for skillfully working out his ideas in a material form. Always impatient to be doing something, he could not bear the restraint and inactivity of the schoolroom.

He early learned the trade of a watchmaker and optician, in which business he started for himself in his native town, and to which the major portion of his life was devoted. He still retains his fondness for watchmaking, and says that of all the various lines in which he worked, that was to him the most interesting. He soon became acquainted with Prof. Moenighausen, for whom he constructed various physical apparatus, and whom he assisted in experimental work. Together they experimented with electric lamps, and, besides understanding how to make an electric arc, they knew the use of the common air pump and blowpipe, the method of producing a vacuum by mercury, the carbonization of wood, and the conducting properties of the carbonized material, the fact that carbon could be brought to incandescence by placing it in a vacuum and sending a current through it, the practical identity of the coefficients of platinum and glass, etc. Goebel also constructed a magneto machine during this period, and other electro-magnetic apparatus.

It was in 1848 that Goebel set sail for this country, accompanied by his wife and two children. The sailing vessel in which he took passage required ninety day for the trip, and it was in the early part of 1849 when he landed in New York. He immediately began his business here, first at 391 Monroe street, then at 271 the same street, later at 500½ Grand street, and afterward at 468 Grand street. He soon began to work on electrical devices, and at one time so successfully exhibited an arc lamp on the roof of his house, that it called out the fire department. He then turned his attention to incandescent lamps, and in the early fifties, it is claimed, constructed lamps, first made from Cologne bottles, and afterward from tube glass, which, from the form of the filament, are known as the "meat-saw" lamps, and which were illustrated in The Electrical World of Feb. 4, 1892.

The hairpin lamp was the next form of lamp which he constructed, the leading-in wires being made of iron, platinum or copper, or sometimes even of other metals. He also made numerous other lamps of the meat-saw type from time to time, and during the period from 1860 to 1880 he gave away many lamps of his construction and exhibited many others to his friends. No six months elapsed, he claims, during which he did not make or exhibit some of his electrical devices. The story of his big telescope, which he exhibited in Union Square and elsewhere in New York City, and with which he used his incandescent lamps to attract customers, is too well known to need repetition here. The telescope was of his own construction and he was justly proud of it. He afterward placed it in the custody of a friend to take to England and sell for him, but that was the last he ever heard of it, and he only received $10 or $15 for an instrument which was worth many times that amount.

In 1881 Mr. Goebel became connected with the American Electric Light Company, and for some time made carbons for it. The materials and methods used in the construction of these lamps are fully described in The Electrical World of Feb. 11, and in the issue of April 22 may be seen sketches of a number of the tools which Mr. Goebel used for making his filaments. The details of these various types of lamps have been so fully set forth in the recent trials that it seems unnecessary here to again enter into them. The reason Mr. Goebel gives why his lamps never came into practical or commercial use is the lack of a suitable source of current. He was obliged to rely upon primary batteries, which were both expensive and unsatisfactory. He did not hear of the application of the dynamo to electric lighting, he claims, until after his connection with the American Electric Light Company in 1881 or 1882, and it was about this time that he first heard of Edison and his work.

Whatever may be the real value of Goebel's work it certainly forms an interesting chapter in the history of the development of the incandescent lamp. The man is not less interesting than his work. Although nearly four score years of age he is still erect, his step elastic, his eye bright and his manner kind and engaging. His face, while not that of a scholar, is of the reflective type and bears evidence to the fact that the most of his life has been devoted to experimental research, and he himself states that he was never so happy as when working out some of his invention or discoveries.

Mr. Goebel and his wife, who died some years ago, were blessed with fourteen children, seven of whom are still living. Of the accompanying portraits of Mr. Goebel, one is reproduced from a recent photograph and represents him as he is to-day; the other is from a photograph of an oil painting which was probably executed about the time he made his early lamps.

The General Electric Company's Exhibit at the World's Fair.

For some time past considerable interest has been manifested as to the form and extent the display of the General Electric Company at the World's Columbian Exposition would take, since it was known that the resources of this organization were so extensive and the fields which its work covers so various that an exhibit of great value and interest was naturally anticipated. About one year ago the various factors now combined to make the General Electric Company began to consider the matter of making a display at the coming World's Fair, and made an application for allotment of space in the Electricity Building. On account of the difficulty of deciding the details it was late in the fall before the present allotment of space was finally made. Under this arrangement the General Electric Company has secured the central spaces of the Electricity Building, five in number, including the very centre of the building. Upon a space of 34 feet in diameter, the company has erected a beautiful shaft, shown in The Electrical World of April 1, 1893, which, with its decorations of thousands of electric lamps, will form an appropriate centrepiece for the entire electrical exhibit. The company has also secured the entire length of the transept from the east door to the west door, and the space in the nave similarly situated, and immediately under the centre, in addition to the space on either side immediately under the galleries and connected with the central areas. This central space comprises over one-fourth of the ground floor of the building and fully one-seventh of the entire space available for exhibits.

When the work of preparation for the Exhibition first began the General Electric Company obtained a contract for the temporary light and power plant which by the fall of 1892 called for four arc lighting machines, two 100 kilowatt 500-volt power generators and two low tension incandescent machines. From that date until about a month ago this plant has worked with entire success under the most adverse circumstances, and, while intended only for a temporary installation, has continued many months beyond the time for which it was designed. Many motors have been connected with the circuits throughout the grounds and buildings for the purpose of operating hoists, saw mills, pipe-cutting machines and various other pieces of apparatus, and in appreciation of this valuable service the Exposition has awarded to the General Electric Company the exclusive contract for furnishing motors from 1 to 100 kilowatt capacity for service during the present year.

In the lighting of the grounds and buildings, the General Electric Company will take an important part, having an aggregate of 3,500 2,000 c. p. arc lamps. The Thomson-Houston system is used exclusively for the illumination of the Manufactures and Liberal Arts Building, after designs prepared by Mr. L. Steiringer. From the same source came the design for the electric fountains, constructed by the General Electric Company at the west end of the great basin facing the Administration Building. These fountains, of which an illustration and description will be found in The Electrical World of Jan. 21, 1893, surpass all previous efforts in this direction. They are supplied from the high-pressure system, placed for the fire protection of the World's Fair by the Worthington pump manufacturers, each of the two fountains requiring the full capacity of a 16-inch main under 100 lbs. pressure. The difficult task of constructing watertight casemates with floors seven feet below the level of the water in the adjoining lagoon was successfully performed by the Fitz Simons & Conell Company. Thirty-eight of the General Electric Company's 90-ampere projector lamps, with burnished silver parabolic reflectors, will concentrate their rays for the illumination of the streams of water which are projected through nearly 400 apertures. The operation of the fountains will be directed from the northeast tower of Machinery Hall. The current for this illumination will be supplied by four 175-kilowatt Edison bipolar generators, the three-wire system being used, and lamps placed across the mains in parallel. After the close of each evening's entertainment the same machines will be used for charging the electric launches at the charging station located south and east of the Agricultural Building, and which is one of the most extensive plants of the kind ever installed.

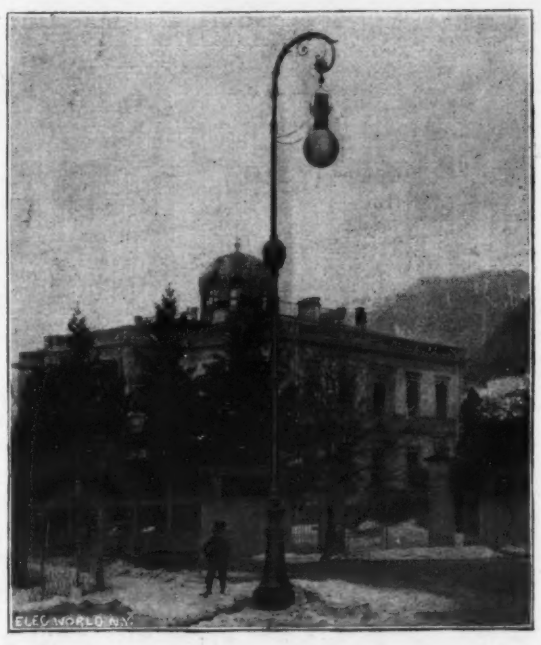
The application of electricity to marine work will be fully demonstrated on the battle-ship the State of Illinois, which will be fully equipped with all the most modern electrical devices of the General Electric Company's type, included several search light projectors, one of which is claimed to be the best ever made, being the 150 centimetre projector, with a 200-ampere lamp.

The use of electricity on railroads will be well illustrated by the Intramural Railway, which is fully illustrated and described elsewhere in this issue. The advantages of electricity over all other forms of motive power are nowhere more completely illustrated than in this elevated railway.

Every modern useful application of electricity will be shown, either in reality or by photograph, in the exhibit proper of the General Electric Company. The first direct coupled engine and dynamo Jumbo, has been loaned by the Edison Illuminating Company of New York, in whose Pearl street station the machine was in service for some 11 years. The incandescent lamp of every voltage and type, and the feeder and main system of distribution, will be fully exhibited, while in the east centre space, the alternating system, with all its devices, will be shown. Across the centre isle the multiphase system will be seen, while the application of electricity to marine service by high-speed engines, directly coupled to compact and efficient dynamos, the searchlight projector, dock and marine hoists, pumping and signaling apparatus, etc., will be shown. The application of electricity to mining has not been neglected, and the transmission of power over long distances will also be displayed, as well as the application of motors to locomotives, derricks and elevators, and especially to the development of the modern street railway.

Arc Lamps on Alternating Current Circuits.

In Europe, where the series system of running arc lamps is seldom used, such lamps are generally connected to multiple arc circuits, and must, therefore, either be provided with a dead resistance, wasting considerable energy for which the consumer must pay, or, by placing the proper number of arc lamps in series, such resistance may be dispensed with. But the lamps are then dependent on each other, are therefore not so steady, and their distribution is attended with difficulties. To overcome these objections the Oerlikon company, in its installation in the city of Chur (Croire), Switzerland, provides each lamp with a separate transformer, which reduces the potential to the required amount. The neat arrangement adopted by this company is shown in the accompanying cut, in which the transformer itself is seen to form a portion of the ornamental lamp post. By



ALTERNATING CURRENT ARC LAMP AND TRANSFORMER.

this means the lamps become quite independent, and there is no waste of energy, except that in the transformer and in a small amount of dead resistance.

Electricity at the Columbian Celebration in New York.

Electricity played no small part in the recent Columbian celebration in New York, a grand searchlight display from ships dressed with incandescent lamps being a unique feature of the show, while the electrical decorations of Madison Square Garden added unusual eclat to the ball given there in honor of the occasion.

In preparation of the event, the various men-of-war had run temporary circuits for incandescent lights; at a signal the currents were turned on simultaneously, and the brilliant glow of incandescent lamps flashed forth like magic. Some of the ships had so arranged the circuit as to outline the hull in brilliant lines; others had lamps in lines extending from the smoke-pipe or mast, while the "Reina Regente" attracted particular attention from her beautiful hull decorations of garlands, crosses and other designs. The English ships were particularly brilliant, the bows, masts, bridges and smoke-pipes being outlined by circuits of lamps.

Before the spectators had recovered from their delighted amazement at the singular beauty of the scene, the searchlights of the ships, following the U. S. S. "Philadelphia," suddenly darted forth their dazzling rays, first horizontally, then converging to a common point in the sky, then spreading out like a fan. When separately trained, the myriad of rays, uneasily and rapidly darting from point to point, brought to mind the thought of a frantic army of ghostly spirits attempting to break through bounds from which they are always violently repelled.

Exhibitions in signaling were given with the searchlight rays, a flash in one direction or the other corresponding to the dot or dash of the Morse telegraphic code. The "Australia," of the British fleet, was equipped with a signaling device by means of which an operator sitting at a keyboard controlled a shutter connected with one of the searchlights, so that a depression of a key permitted a momentary flash to go forth, an ingenious combination of which formed a telegraphic code. The signals thus transmitted can be read 40 miles off. The American ships signaled by means of colored electric light globes, controlled from a keyboard, whose combinations formed letters.

Probably the most elaborate electrical decoration ever attempted was carried out in the Madison Square Garden for the ball that occurred the night of the naval review. The main entrance and reception platform were flanked by enormous silver dragons with outstretched wings studded with electric lights and with eyes of flame. The foliage was decorated with fireflies and other pretty conceits formed of miniature electric lamps. Surmounting the reception platform was an enormous fan-shaped design of electric lamps, and among other notable sights was a pretty arch with its sides studded with electric lights in the form of sprays of lilies of the valley; from the keystone was suspended a silver Cupid bearing a garland of electric lights in his hand, and at the base of the arch stood a bizarre Japanese figure holding a wheel of electric lights, which were, by means of appropriate mechanism, made to constantly twinkle and change color, giving the appearance from a distance of a revolving wheel. Miniature electric lamps were used by the thousands, the gallery and balcony rails being studded with them, and they nestled everywhere among the flowers and plants.

In the banquet hall was a floral representation of the United States Capitol at Washington, with the surrounding grounds. The Capitol building was constructed of flowers, and at the windows glimmered incandescent lamps. In the centre of the balcony was a large silver spray of electric lights, and miniature incandescent lamps were also used here in myriads for the purposes of decoration.

Another innovation was the telephonic review of the river parade by Supt. Byrnes. Telephone booths had been placed at intervals of about ten blocks on the piers along the river. The Superintendent sat in his office and from these booths received a continuous telephonic report of the progress of the procession along the river.

The Lighting of Frankfort-on-Main.

The report of the experts, Messrs. W. H. Lindley and Oscar von Miller, appointed by the Special Commission, on the tenders submitted for the lighting of Frankfort, is a voluminous and withal interesting piece of work. Acting on the recommendation of the experts, the Special Commission propose to divide up the work into three groups, as follows: 1. Boilers; 2. The complete electric plant, including the steam engines; 3. Cables.

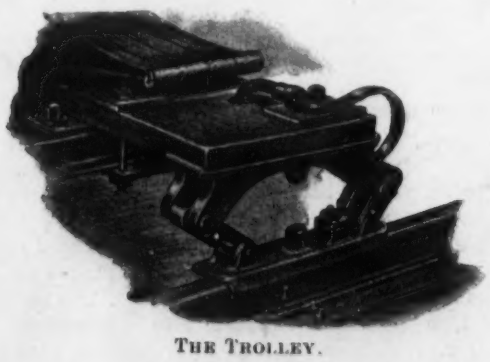
Part III. of the report of Messrs. Lindley and Von Miller is of considerable interest, as it deals with the chief technical points of the system advocated and with the arguments proposed against it. It has been urged that the alternating current system with transformers and a low potential distribution network such as has been proposed would be objectionable on the ground of the unnecessary additional cost of the secondary network, but it has been proved that on the contrary the cost of numerous small transformers would more than outweigh the additional cost of the secondary means. It has also been urged that this system would add to the probability of telephonic and other disturbances, but the experience with secondary distribution systems in Heilbrun, Zurich, Carlsbad and other places does not confirm this; and furthermore, provision is made in the scheme for disconnecting the network at certain junction points and enabling the secondary system to be divided up into a number of smaller secondary systems in case any real difficulties should arise. Another of the objections brought against the system is that the secondary network would introduce a further loss between the transformer stations and the points of consumption, and therefore involve the same disadvantages as the continuous current system, but it has been shown by calculation that the consumption of energy would be on an average 12 per cent. less than if numerous small transformers were used. Again, the maximum loss, one and five-tenths per cent., in the secondary network could not call forth any objectionable fluctuations in the voltage, as the voltage of the secondary network is regulated and kept constant from a central station, so that the potential difference in the transformers would be equalized by the use of the secondary network. The advantages of such a system may be summarized as follows: 1. The introduction of high potential currents into every house is avoided; 2. The inconvenience to consumers attendant upon the installation and care of the transformer in the house is entirely done away with; 3. The current losses are reduced from 10 per cent. to 15 per cent. by the use of large transformers capable of being temporarily switched off; 4. The cost of installation and operation is materially lessened. On these grounds the alternating current transformer system with low potential distribution network is recommended as best adapted to the conditions in Frankfurt.

BEFORE many other questions could be settled one of the most important problems to confront the World's Fair management almost at the very outset was the question of transportation of visitors from place to place within the enclosure at Jackson Park. While we are apt to consider the areas covered by expositions as too small to make such considerations leading ones, it was early seen that in this case at least they must assume considerable importance. At the Paris Exposition a surface road, hugging closely the confines of the grounds, and operated by steam, furnished the means of transportation at the sacrifice of the safety of those who walked. Such a plan, while the best that had been devised at that time, was not deemed suitable to the present undertaking, and an elevated structure was at last decided upon as the sine qua non. So much having been decided the rivalry became fierce between competitive systems, and for a time it seemed sure that the movable sidewalk, a large working model of which had been erected on the grounds, and which had for months been satisfactorily demonstrating its capabilities, was likely to be successful. From the very start steam competition was out of the question, and this practically limited the motive power to electricity. The Western Dummy Railroad Company were finally successful in the competition on a bid of 25 per cent. of the gross receipts and a ten cent fare.

Work was commenced early last fall on the elevated structure, which is a double-tracked affair supported for the most part by the 12×12 square sets of pine, and surmounted by I beams—two to the track. These latter are usually 25 feet in length and are carefully bonded to furnish the main return for the current. This bonding consists of from 2 to 5 copper strips, according to the situation, each 2 inches wide and 1-16 inch thick, riveted cold through holes in the web of the stringers that have been carefully reamed to afford good electrical contact. These rivets are of copper, ⅞ inch in diameter and 2 inches long, and two of them are used in each bond. The outer strip of each bond is looped into an eye for the ready reception of the terminal of a conductor connecting with the track above, as will be described further on.

Transverse to and lying on these longitudinal iron stringers are the sawed crossties arranged as in the Manhattan Elevated structures, upon which in similar manner are spiked the tracks and the longitudinal guards.

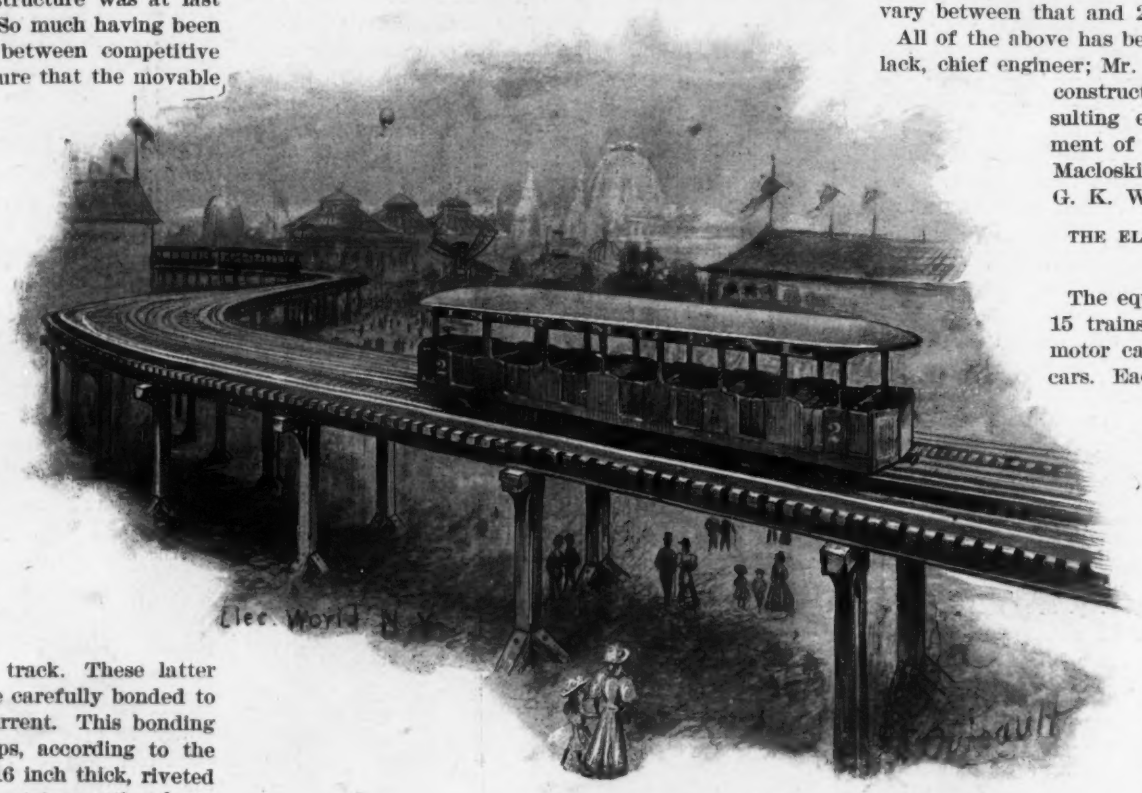
In addition to the four rails of the double-track road, there are others that will need explanation. It will be necessary to understand at the outset that this whole installation is of a temporary character, and, while this does not imply that it has been cheaply (in the sense of insufficiently) built, still it has been constructed with the view of so using the material as not to destroy its use-



THE TROLLEY.

fulness for other purposes when no longer required here. For this reason the conductors that are used for carrying the current to the motor cars are T rails of exactly similar design and weight (60 pounds to the yard) as the track rails, and these, which are called the "working conductors" and take the place of the trolley wires of the electric street railway, are laid parallel to the tracks 18 inches to one side and elevated so that their faces are about 12 inches above the crossties. This elevation is attained by placing them on blocks at intervals of six feet approximately, which themselves are supported upon the crossties each by two iron legs securely fastened to the latter. The wooden blocks which directly support the working conductors serve as insulators, and are themselves kept from standing water which might accumulate on the ties by the iron legs before mentioned. That these blocks may not absorb moisture from the falling rain or from the atmosphere, they are thoroughly treated with cresote.

Parallel to the working conductor and as close to it as possible is another rail similarly elevated on blocks. This is the feeder, and extends along both trolley rails for about three-fifths of the distance from the power house to the further terminus. These two lines of rails—the working conductor and the feeder—are laid so that their



VIEW FROM THE POWER STATION.

joints come together and are bonded in similar manner to the track rails with the loops or eyes facing each other, and connection is made between the two by inserting into these eyes the two legs of a hairpin-shaped wire and electrical connection insured by soldering. Thus the current is fed to the working conductor at every rail length.

The track rails are also bonded in similar manner, and each rail of each track is connected to the girder beneath by a wire which is soldered into this eye. Thus the four large girders form the electrical return for the current which passes from the wheels to the track.

As will be seen from the above, the trolley rail is placed to the side of the track. Heretofore when a third rail has been used it has been placed in the centre. There has perhaps been but one exception to this rule, viz., in the Portrush railway erected by Siemens. In that road the third rail was also placed at the side, but the conditions were different, as that was a surface road and for purposes of insulation it was necessary that it be elevated, and at road intersections it was required to be elevated high enough to permit the passage of teams beneath. In this case, however, no such reasons for elevating it existed, but it was found that with the large motors that were required there would not be room enough with a centre rail to give proper clearance between motor and rail. By placing it at the side as much room as required would be attainable, the sliding contact or shoe would always be accessible, and the switching arrangements would be simplified. The only apparent disadvantage was that this required the employment of a double set of trolleys—one on each side of the car, which involved an additional expense of but $20 per motor car, and this was so trivial that it was not for a moment considered.

It is calculated that in average work the drop at the end of the line—about 3 1-6 miles from the station, will be 40 volts, and with maximum load, 70 volts, or with 5,000 amperes about 8 per cent. loss.

The actual length of the line is 14,800 feet of double track and 1,900 feet of single track. This, as will be seen from the accompanying map, embraces three sides of the grounds, passing by or near to many of the principal buildings, and terminating at either end in a loop. At these loops it was originally intended that the passengers should be discharged on one side, and the train hauled empty around the loop, and stopped on the other side for receipt of passengers, thus obviating the usual interference of outgoing and incoming crowds. It was found impossible to carry out this plan, however, and passengers are discharged and received at the same station on the loops, as elsewhere. There are ten stations in all, and at each of these, with a few exceptions, the track is caused to rise, thus serving as a check to approaching trains and an assistance to those departing. Otherwise the track is essentially level, varying from that to 0.42 per cent. and 1.5 per cent. grades, and in one short stretch reaching 2 per cent. The curves at the terminals are short, viz., 100 feet radius, and the others vary between that and 2,000 feet.

All of the above has been the work of Mr. C. P. Matlack, chief engineer; Mr. H. B. Quick, superintendent of construction, and Mr. K. I Sloan, consulting engineer. The electrical equipment of the track is due to Mr. C. H. Macloskie, electrical engineer, and Mr. G. K. Wheeler, consulting engineer.

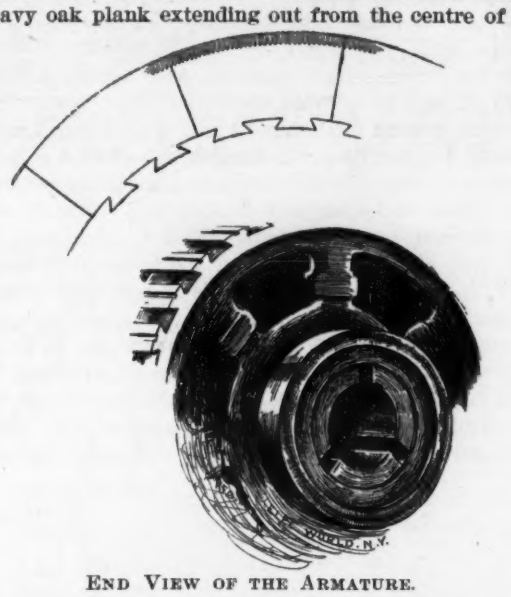
THE ELECTRICAL AND ROLLING STOCK EQUIPMENT.

The equipment of the road consists of 15 trains of three open trailers and a motor car, together with 3 extra motor cars. Each of these cars is 50 feet in length. The trailers when loaded will weigh 22 tons and the motor cars 30 tons. Each motor car is equipped with 4 motors, one to each axle. These were specially built for the purpose by the General Electric Company, and are of the T.-H. 4-pole ironclad type. The armatures are Gramme ring with bar winding with three turns to the coil and are cross-connected so as to require but two brushes—carbon being used. They are single reduction, so geared as to work at a maximum speed of 35 miles per hour, are capable of an output of 133 h. p. with safety—thus giving a total capacity for each motor car of something over 500 h. p. The motors themselves weigh about 4,000 pounds.

ON THE STATION.

The trucks were made by the St. Louis Car Company and the Jackson & Sharp Company, and do not differ from those usually seen on elevated railroads elsewhere, except that on the motor cars they are specially braced to meet the horizontal effort of traction.

On each motor car there are four trolleys or sliding contacts—two on each side. These are attached each to a heavy oak plank extending out from the centre of the



END VIEW OF THE ARMATURE.

trucks some 18 inches beyond the wheels. They consist of an iron frame with two arms as shown in the cut, having pins which loosely hold two iron links, to which is attached the shoe proper. This is of cast iron, about 12 inches long and so shaped as to fit loosely upon the face of the rail. All of this portion of the trolley is carefully insulated from the truck, but electrical connection is made between the shoe and a binding post on top of the wooden support by means of a bundle of flexible copper strips. The link connection permits of considerable vertical movement of the shoe and also of the adjustment of the latter to the motion of the car in either a forward or backward direction. The first shoes made were of brass and were cast with a lug on their upper side corresponding with another one on the iron support above. These were intended to form supports for a spiral spring in compression for the purpose of insuring better contact between the shoe and the track. Experiment, however, has shown that the weight of the shoe is sufficient for this purpose, and the spring has been discarded. Iron has also been substituted for brass as being cheaper and answering equally well.

Located midway beneath the two trucks are the resistances, of which there are eight on each car. These are the standard T.-H. resistances of 30 ohms each and are capable of carrying 50 amperes without dangerous heating.

All of the motors are, of course, carefully insulated from the trucks. Each motor frame, however, is tapped to a main extending to the controlling appliance, and on the other end of the circuit each trolley is also tapped to a main extending likewise to the controlling switches.

THE CONTROLLING APPLIANCES.

The controlling appliances are located at the front end of the car in a compartment set aside for this purpose. It is what is known as the "series parallel controller" and was especially designed for the purpose by Mr. C. H. Macloskie, to whom many of the electrical features of the equipment are due. This consists of two drum commutators not unlike those heretofore used on street railways, but the method of connecting up the motors and resistances is entirely new and tried on this road for the first time. The motion of these drums is also produced in a way new to electric railway practice—compressed air being employed as the motive power in a manner quite similar to that employed to control the link movement on ordinary locomotives. The accompanying diagram will make its operation clear.

A and B are two single-acting compressed air cylinders with their pistons, and C, D are two similar cylinders connecting with each other through the chamber F by the pipe E. These two are oil cylinders. The pistons A and C, and B and D are rigidly connected by rods broadening out into ratchets M, N, engaging in opposite sides of the toothed wheel O, which is attached to the spindle of the controlling cylinder. The chamber K is connected at one side with the compressed air reservoir and at the other with the two pipes A" B', connecting respectively with the air cylinders A, B.

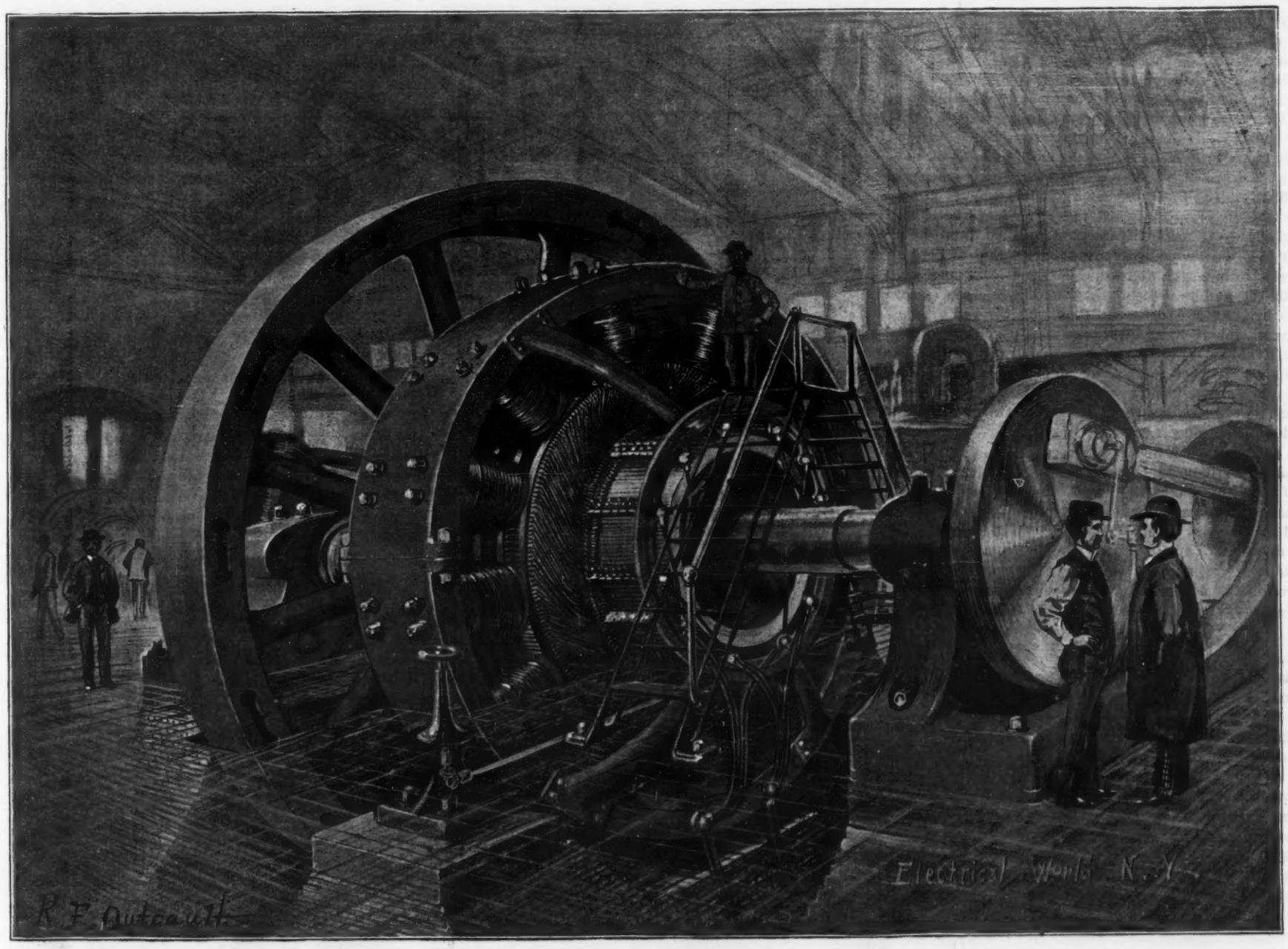
P is a metal shaft which is revolved by the hand lever L. Within the chamber K it operates a three way valve, admitting compressed air into pipes A' or B' as the lever is moved in one direction or the other, and in the chamber F opens the connection between C and D in either position, but closes it when the lever L is central. The operation of the apparatus is exceedingly simple. When air is admitted to A, the ratchet M is moved to the right, and the controller spindle is revolved in the same direction. The oil in C will be forced into D, and both D and B will be moved to the left. If the lever L be pulled to its central position, the valve in F is closed, the oil can no longer be forced from C into D and the controlling cylinder remains stationary. If L be pulled past its central position the valve in F is again opened, air is admitted into B' and B, the ratchet N moves to the right and oil flows from D into C, and the controlling cylinder is revolved in the opposite direction. By this simple device the labor of moving the switches which are proportioned to handle 1,000 amperes is entirely done by the compressed air.

We omitted to mention that all of the trains on the intermural electric railway are provided with air brakes of the New York Air Brake make. These are supplied with compressed air, as are also the cylinders of the controlling device, by means of an air compressor manufactured by the same company and driven by a small T.-H. motor of the ironclad type—both located in the motorman's compartment or cab.

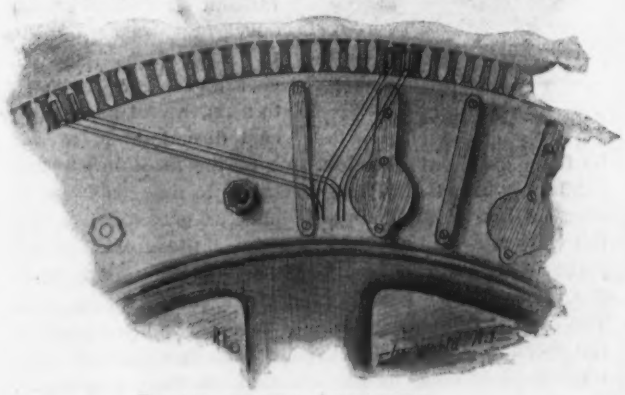
In addition to these, there is also located here a large main motor switch by which the current can be cut off from the motors and controllers.

As before stated, the method of connecting up the four motors is new. In the present method, on starting, the four motors are connected up in series as in No. 1. By this arrangement with a given current the torque is four times that obtained when the four are in parallel. The next step is to connect the four motors up in series of two in parallel with each other, and the last arrangement is to throw them all in parallel. It will be seen that by this method with a given resistance in circuit, the maximum torque is given at the start when it is most needed, and that by successive steps the current is increased.

By the proper throwing in and out of resistances in connection with the increasing counter electromotive force as the speed increases, almost any desirable curve may be obtained, but without going into the details or refine-



THE 2,000 H. P. GENERATOR AT THE INTRA-MURAL RAILWAY POWER STATION.



DETAIL OF THE ARMATURE.

ments, the advantage of this arrangement over the old one may be shown by the two hypothetical curves A and B, which are types of starting curves according to the old and new methods respectively. Thus it will be seen that in A the curve rises quite rapidly at first and is not checked until the counter electromotive force rises sufficiently to be of importance. In this curve it is evident that great care must be exercised in starting, else in the

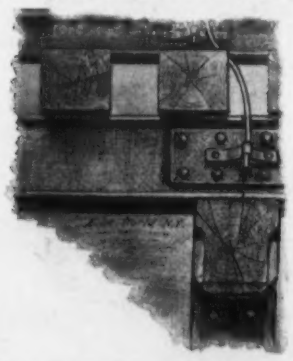
Feeder and Working Rail Connection.

endeavor to obtain sufficient torque a fuse will be blown or the motor damaged. In curve B, however, with the same torque, the curve rises but gradually, and the start is accomplished with less danger. There will, however, be more danger in stopping or breaking the current in the latter curve than in the former by reason of the greater self-induction in equal increment of time, but the curve as given in B is, in fact, modified by means of the resistance thrown in, so as to obviate in a great measure this difficulty. The three diagrams given do not, of course, tell the whole story. There are two other steps between them which are transitional; thus between No.1 and No. 2 one pair of motors is momentarily short-circuited, while the other two are in series, and again between No. 2 and No. 3 two of the motors are short-circuited, while the other two are in parallel. In this way and by the use of the resistances violent irregularities of the curve may be entirely avoided.

A somewhat novel feature of the cars not before noticed may be mentioned here. It will be seen from the drawings that the seats are arranged in pairs transverse to the length of the car, and face each other. Entrance to each pair of seats is afforded by a pair of doors which slide out of sight in opposite directions into the framework of the side of the car. The novel feature referred to is that all of these doors are controlled by a lever at the end of the car. There are two of these levers, one for the doors on each side, and when a station is reached the conductor by pulling the proper lever opens all of the doors on the side next to the platform, and when the cars are ready to start simultaneously closes them all again.

THE CAR HOUSE.

This is located at the extreme southeastern end of the park and is a substantial frame structure covering an area of 150×260 feet. Here are located all the offices of the engineers and other officials of the road, together with the side tracks for housing the cars when not in use, the repair tracks and the shops. There are eight tracks in all within this inclosure. Four of these, about 220 feet long, each capable of holding a train of four cars, are intended for storage alone and have no pits. The other four, extending the full length of the building, are built over pits some four feet deep, as is common in car repair shops, and on these tracks the cars are run whenever repairs are needed or examination seems desirable.



Return Circuit Connections.

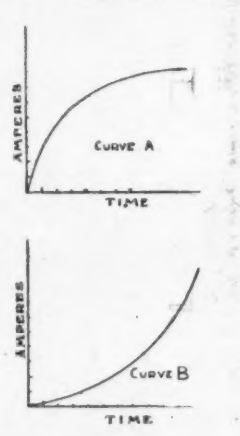
THE POWER HOUSE.

The power house is located just east of the car-house, its front line being tangent to the sharp curve of the track where the road turns from an east and west direction, to a northwest and southeast direction. Here will be found, without question, one of the most interesting exhibits in the whole Park—certainly to those engaged in electrical pursuits. The power plant in this station is for the General Electric Company, what the great lighting plant in the Palace of Mechanic Arts is to its great rival, the Westinghouse Electric and Manufacturing Company. The design and arrangement of this magnificient plant is the work of Mr. B. J. Arnold, who has already distinguished himself in the erection of other important, though less extensive, power stations for the General Electric Company.

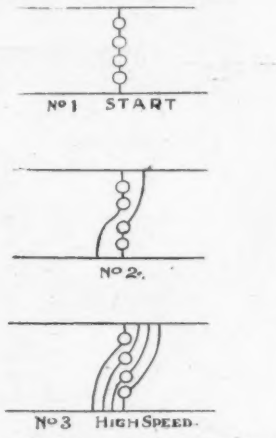
This structure consists of a boiler room 140 feet long and 60 feet wide, and an engine and dynamo room 140 feet by 87 feet. In the former is located the bank of Babcock & Wilcox boilers, ten in number, rated at 300 h. p. each. These are fired by oil supplied through jets extending into the combustion chamber, fed by 2-inch pipes connected with the tanks at the south boundary to the Park. On the same floor with the boilers, or, rather, in a pit separating the boiler room from the engine and dynamo room, are located the Allis jet condensers and air pumps, connected to the Allis engines; a Conover jet condenser and air pump, coupled to the Williams engine, a Worthington duplex jet condenser, coupled to the Greene engine; a Deane single-acting jet condenser for the McIntosh & Seymour engine, a Smith-Vaile duplex boiler-feed pump, and one Gould triplex boiler-feed pump.

On the engine room floor, which is raised some 10 feet above the boiler room floor, are arranged, beginning at the east end, a 22×44×48-inch Reynolds tandem compound Corliss engine, built by the E. P. Allis Company, coupled to a direct 500-kilowatt multipolar generator. The armature of this machine overhangs the bearing of the shaft. Next comes the Hammond-Williams vertical engine, cross compound, 22×44×36 inch, driving a similar generator 500 kilowatt capacity, and capable of working up to 1,200 h. p.

In the centre of the floor is the great 2,000 h. p. cross compound Reynolds-Corliss engine, built by the E. P. Allis Company, which operates the 1,500-kilowatt multipolar generator, later to be described in detail. This is direct connected. West of this stands a 13×23×22 McIntosh & Seymour tandem compound engine, coupled direct to a 200-kilowatt multipolar generator, and at the west end of the building is located a 20×38×48 tandem compound Greene engine, belted direct to a 500-kilowatt multipolar generator. This belt is 48 inches in width, and is supplied with an idler or tightening pulley, furnished by the Eclipse Clutch Works, of Beloit, Wis.



Types of Starting Curves.



Method of Connecting Motors.

Thus, this constitutes by far the largest single exhibit of machinery in motion, and, as an illustration of the various methods of driving generators adopted by the General Electric Company, it is also comprehensive. While all of these generators are interesting, that which will attract the greatest attention is the great 2,000 h. p. generator in the centre of the floor, driven by the Allis engine. This is the largest generator (in output) ever yet constructed, and, although rated as a 1,500-kilowatt generator, can be worked up to 3,000 h. p. if necessary.

THE GREAT 2,000-H. P. GENERATOR.

This machine, which is fairly entitled to the place of honor which it occupies in the centre of the building on account of its size, has another claim upon our attention from the manner of its construction. On account of its size, the different parts of which it is composed, after having been shaped at the various shops and foundries in which they were made, were shipped separately and put together for the first time in this building. Thus the shaft, hub and spider were supplied by the E. P. Allis Engine Company. These were shipped in one piece, and constitute the heaviest shipment; the flywheel was shipped in ten pieces, the sheet iron, after having been stamped to size and shape, was sent loose, and all the minor parts were boxed and forwarded ready to be assembled. The two field yokes, which together surround the armature, formed the second heaviest pieces, and next to these came the flywheel sections and the 12 field magnet spools, which were forwarded ready wound. The estimated weights of the parts are:

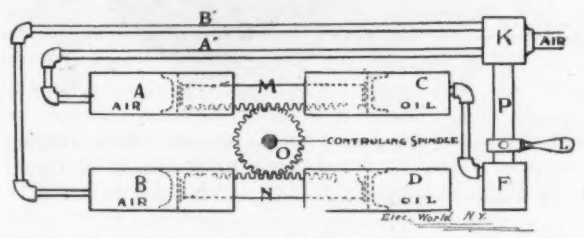
Upper magnet yoke with poles, spools and windings	39,000 lbs.
Lower " " " " " "	41,000 "
Weight of field magnet complete	80,000 "
" armature	73,600 "
" commutator	12,400 "
Total weight of dynamo	180,000 "

Some of the dimensions are as follows:

Diameter of armature	10 ft. 6 in.
Face of armature	36¾ in.
Diameter of flywheel	21 ft.
Face of flywheel	24 in.
Depth of rim of flywheel	20 in.
Number of spokes	10
Diameter of commutator	7 ft. 6 in.

On account of the great difference between the internal and external diameters of the hub of the armature, it was necessary to take precautions against fracture or warping due to shrinkage. The method employed to obviate this danger was unique and interesting, and worthy of our attention.

The hub was cast with three slots at an angle of 120 degrees with each other, extending radially so as to allow for a maximum contraction as the casting cooled. When all was cool, these slots were filled with molten iron, thus making the hub solid, and a steel ring 7 inches broad by 4 inches deep was then shrunk on to a seat prepared for it, immediately surrounding the inner terminals of the slots, and thus both solidity and strength were obtained and internal strains avoided. The hub and shaft were shipped in one piece, and weighed, when received, 56 tons. The shaft itself is 25 feet long between centres, and 24 inches in diameter. Its main bearing is 22 inches in diameter, and 42 inches long. The hub, which was shrunk into the shaft, supports at the end of its six heavy spokes a rim upon which are set 29 bars parallel to the shaft, each grooved longitudinally with a dovetailed slot, into which fit similar projections stamped



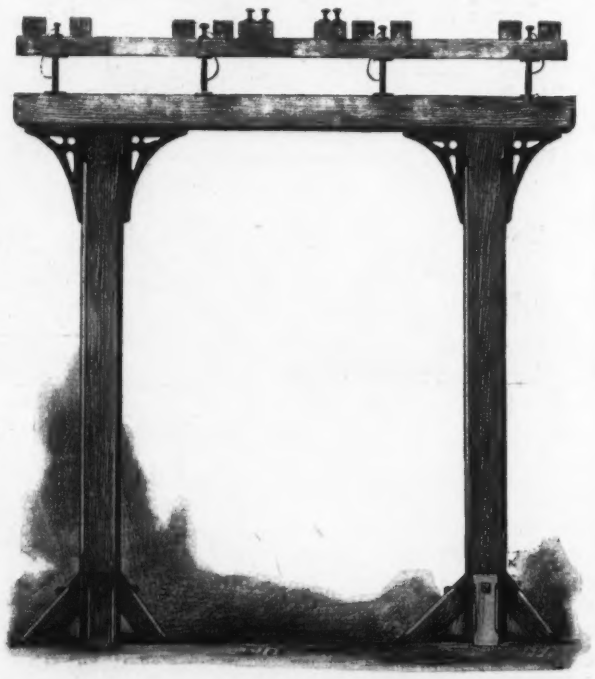
Pneumatic Apparatus for Controlling Switches.

into the inner edge of the sheets of sheet iron, of which the armature core is built.

THE ARMATURE CORE.

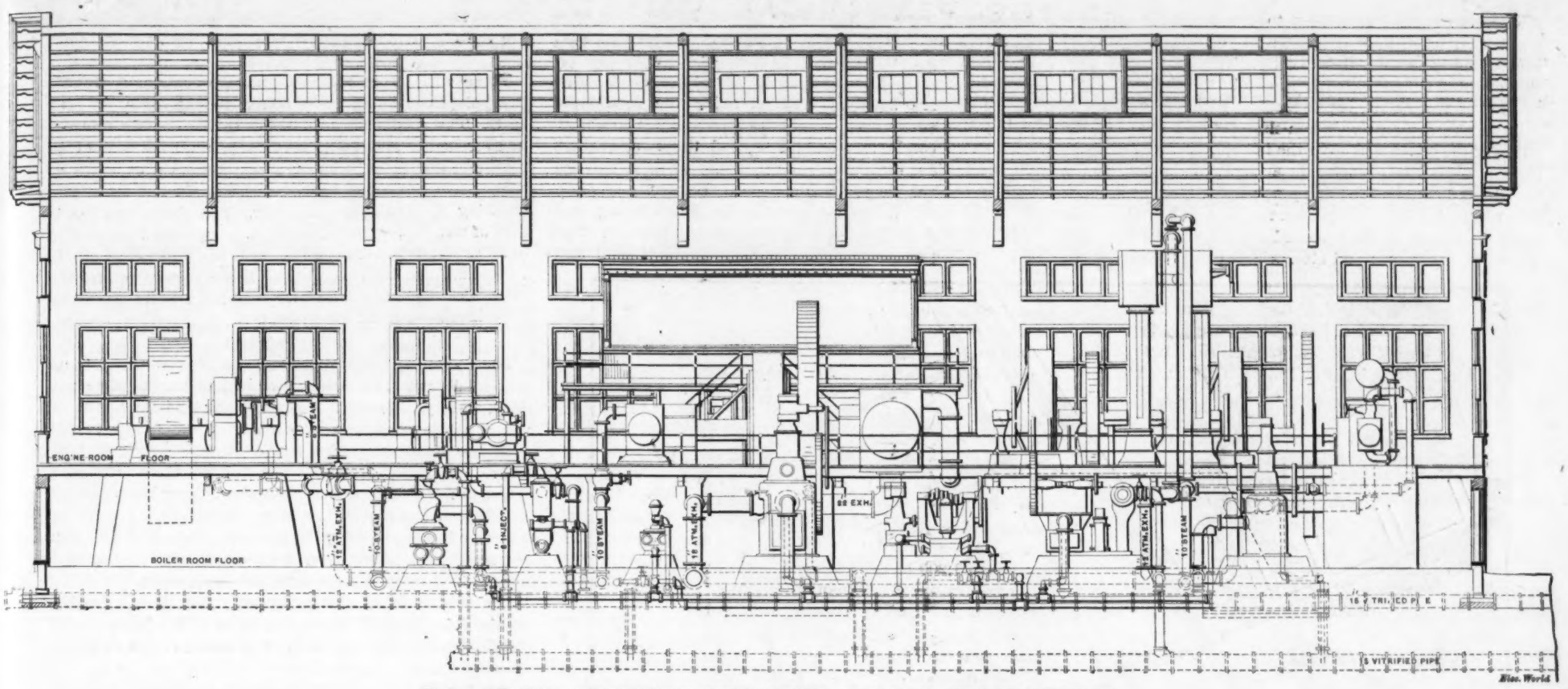
The armature core was built up of ordinary sheet iron .017 inch thick, cut with lugs on the inner side for the slots before mentioned, and of such a length that 9 of these sheets, set end to end, complete the circle and lap over just one-half a length. Each sheet has two dovetails on its inner side just corresponding in distance apart with the distance between the slots into which they are to slide. Thus, when the ninth segment is placed in position, the dovetail in its lapping portion takes into the same slot as the first dovetail of the first segment. Additional segments are added, with their shorter sides abutting, the segments of each circle lapping the joints in the preceding circle, and thus the armature core is built up spirally. The dovetails of each segment are introduced into the slots at one end, and the sheet is pushed along until in place.

When a thickness of 3 inches has been thus built up, a brass section 1 inch thick with radial openings is slipped on, and the completed portion of the core tightly compressed. In this case, a large number of small hydraulic jacks were employed to force the sheets of iron into intimate contact. The brass plates are allowed to remain in position, the radial openings answering for ventilating ducts. Upon this another section is built in similar manner, and so on until the required number of sections are completed. There are in this armature 9 of these sections and 8 ventilating sections, and 17,200 pieces of sheet iron, weighing 25 tons, were used in its construction. It

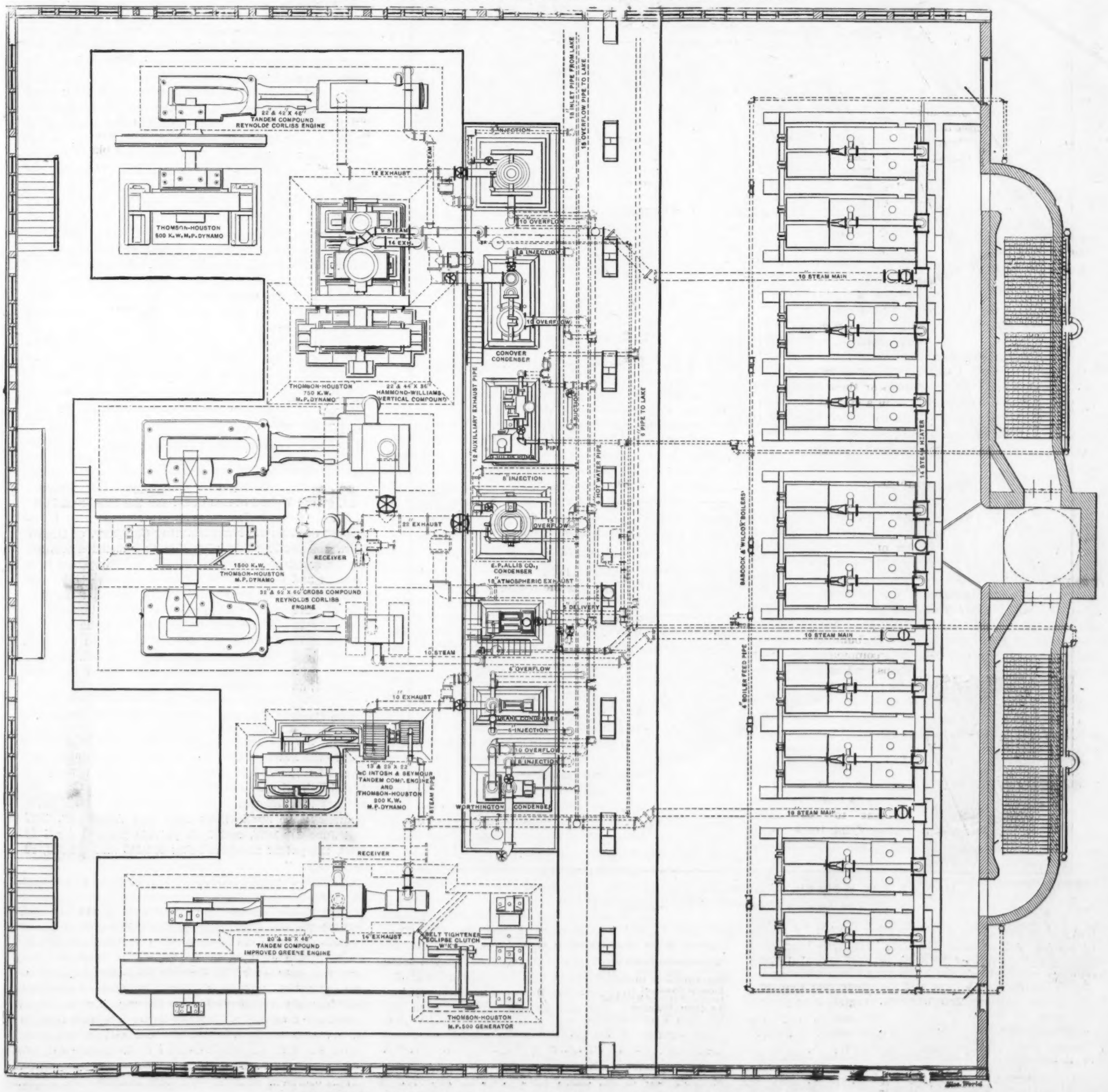


Section of Track Showing Electrical Connections.

took six days to press the sheet iron on. Next, the washers are put on. These consist of two large cast iron rings weighing 4 tons each, which have a lesser outside and inside diameter than the armature ring itself, and they are tied together by 29 tie-bolts 1½ inches in diameter, by tightening the nuts on which the layers of sheet iron are strongly compressed. The tie-rods pass under the armature ring, but are not otherwise insulated from the armature core. In this armature the coils are not wound over the ring, but are imbedded in the iron itself. For this purpose, the sheet iron, before it was sent to Chicago, had been stamped with slots near its outer circum-

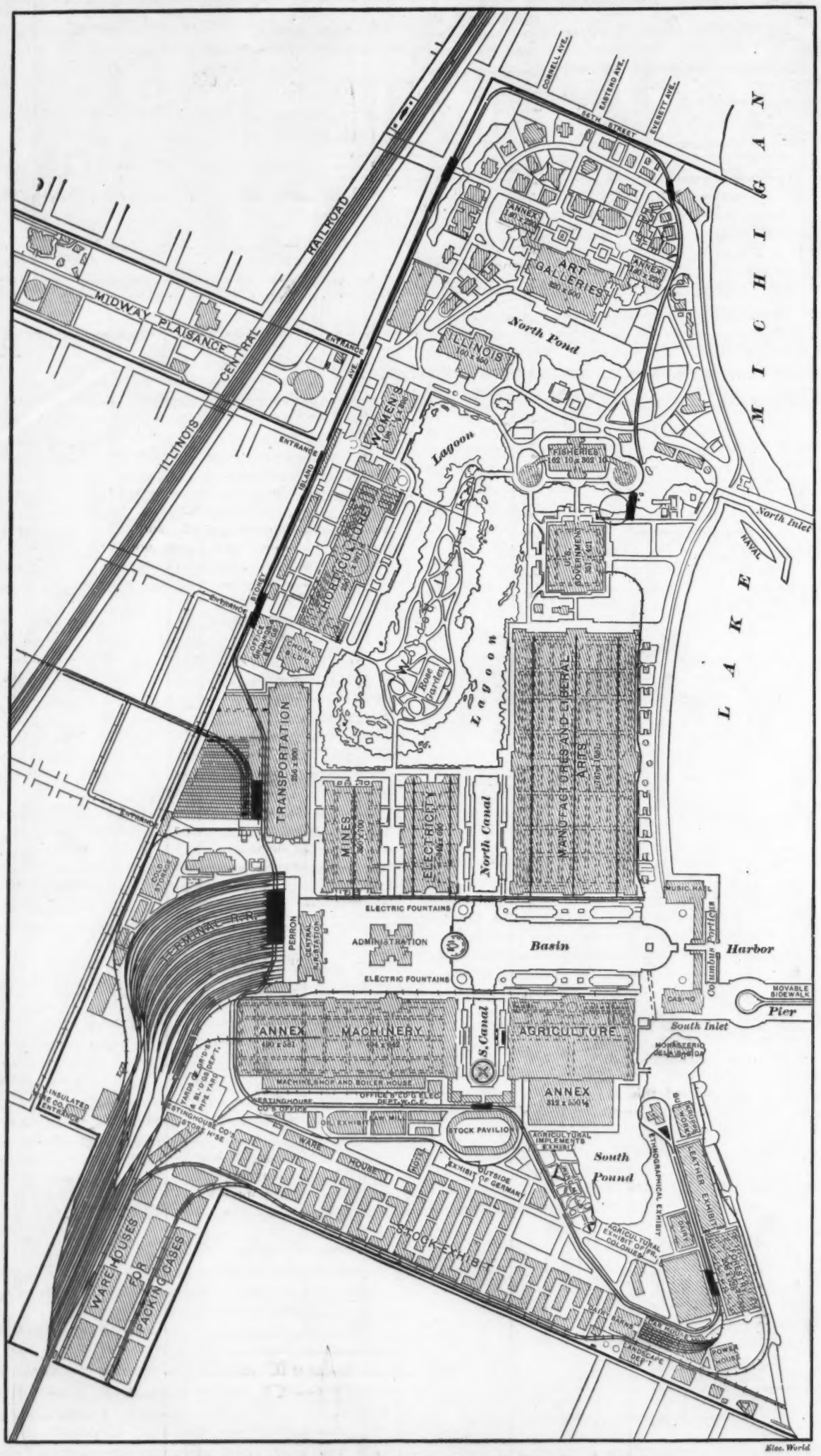


PLAN OF THE COLUMBIAN INTRA-MURAL RAILWAY POWER STATION.



LONGITUDINAL SECTION OF THE INTRA-MURAL RAILWAY POWER STATION.

ference, so spaced relatively to the dovetails on each sheet that when they are placed in position the slots on succeeding layers register exactly. The shape and position of these slots are clearly shown in the sketch. There are 348 of these slots, corresponding with the number of coils on the armature. When first pressed together the edges of the sheet iron gave the interior surfaces of these slots a somewhat rough appearance. This had to be smoothed down, and for this purpose the file was brought into play. A 4-kilowatt Edison motor was belted to four filing machines, which consisted simply of four long files of the proper length and size, which were inserted in as



Elec. World

MAP OF THE WORLD'S COLUMBIAN EXPOSITION GROUNDS.
(Showing Location of Intra-Mural Railway Stations.)

many slots and given a reciprocating motion by means of cranks. All of these 348 slots have thus been filed smooth, and the face of the armature was also filed down by hand.

THE WINDING.

Each coil consists of two turns, each consisting of 2 copper strips in multiple. These strips are ¾ inch wide by ¼ inch thick, and are carefully insulated from each other by mica, and then wrapped together in mica and oiled linen tape. Before inserting these in the slots, channel-shaped tubes of mica were placed in the slots as a further insulation between the conductors and the core, and then the two compound conductors were introduced, radially to each other, and finally outside of these strips of wood were tightly driven in, fixing the conductors rigidly in place.

The two conductors extend beyond the two washers on either side, the outer one extending at each end 1⅜ inches further than the inner one. The ends of both were cut down to form a seat for the side winding, and this seat was perforated with two holes for rivets. The side conductors were then put in position, riveted and soldered. It will be remembered that the two great washers were tied together with bolts. The nuts, by which these bolts were tightened, although screwed home into recesses in the washers, still extended a short distance outward. In order to insure proper insulation against the iron washers, and also against abrasion from the nuts and bolt terminals, the latter were covered with strips of wood, as shown in the detail sketch. This also shows the method of winding adopted over the side of the ring. These side conductors each consist of two copper strips 1⅜ inches broad by 1-16 of an inch thick. These two are carefully insulated from each other, as are the face windings previously described.

THE FIELDS.

These are 12 in number, and are compound wound, the polepieces being each bolted to the yoke by four bolts. The spools are 14⅞ inches by 30⅜ inches internal measurement, and 18 inches deep, and are wound in multiple, the series winding being composed of strips of copper 4 inches broad by ¼ inch thick, two of these constituting the multiple conductor. The shunt winding is also of flat copper strips, doubled, measuring 7 inch by ⅛ inch each. When the fields are in position there is 7-16 of an inch clearance between the polepieces and the armature. The fields and holding-down bolts are carefully insulated from the ground.

THE FLYWHEEL.

The flywheel, which was shipped in 10 pieces and is 24 feet in diameter, 24 inches face and has a rim 20 inches deep, weighs, altogether, 85 tons. Each segment has in its rim a recess of such a shape that when joined to its neighbor it affords space for a dumbbell-shaped key. There are similar recesses on both sides of the rim, and when the segments are put together, these keys, heated to redness, are inserted, and in cooling join the pieces together in a most effective manner. This wheel is also clutched to the armature spider directly through a special clutch, thus removing the torsional strain from the shaft.

The setting up of this great generator was in charge of Mr. John Riddell, master mechanic of the Schenectady Works of the General Electric Company, who came to Chicago for the purpose.

THE ENGINE.

The engine, is a cross-compound Reynolds-Corliss, built by the E. P. Allis Company, having its low-pressure cylinder 62 inches in diameter, and the high-pressure cylinder 32 inches in diameter. The crank discs are 7 feet 4 inches in diameter, fixed on either side of the shaft, and the length of stroke is 5 feet.

The equipment and operation of this road has a much greater significance than its mere size would indicate, for it is practically the first electrical equipment of an elevated road that has even been made. More or less experimenting has been done with electricity on the Ninth Avenue Elevated road in New York, it is true, and the Kansas City Elevated road (so called) has been equipped electrically for some months, but the former experiments, though very valuable as far as they went, were not on such a scale or pursued under sufficiently favorable auspices to lead to conclusive results, and the latter road is merely a surface road, which throughout a portion of its length runs on an elevated structure. The operation of this road, therefore, is expected to demonstrate for the first time the practicability of electricity as a motive power for our elevated roads. Many of the problems involved have been met here for the first time, and much of the work was without guiding precedent. Great credit is therefore due to those who have assumed the responsibility, and the outcome is looked forward to with great interest, but without misgivings, by electricians generally.

Incandescent Lamp Litigation.

On April 17 the Edison General Electric Company and the Edison Electric Light Company applied to Judge Seaman, of the United States Court for the Eastern District of Wisconsin, at Milwaukee, for a preliminary injunction against the Electric Manufacturing Company, of Oconto, Wis., and pending this injunction they asked a restraining order against this company, T. A. Pamperin, J. B. Grunart and George Dyer. They set up the claim that they would suffer irreparable injury, and that the Electric Manufacturing Company was selling lamps at exceedingly low prices and thereby injuring the trade of the plaintiffs and inducing lighting companies to lay in heavy stocks of goods pending the litigation. The restraining order was granted on April 17 to be heard April 21, and was adjourned to May 5.

The General Electric Company's Trolley Patents.

After several years of contention and interference before the Patent Office, two broad fundamental patents have been granted to Chas. J. Van Depoele, covering, it is claimed, all the essential features of the trolley. The patents are assigned to the Thomson-Houston Electric Company; the applications were filed August 12, 1887, and June 18, 1888, and both patents granted April 11, 1893, the patent numbers being 495,443 and 495,383, respectively.

In detail, the claims allowed cover, first, the underneath contact made either by a rolling wheel or a sliding spoon contact pieces; secondly, the converse of these two cases; and thirdly, the reversibility of the trolley pole on top of the car, enabling the contact to be made on either side of the trolley, as the case may be.

The possession of this patent practically means, it is claimed by the interested parties, the entire control of the overhead system throughout the United States. The acknowledgment of the claims under this patent granted to the dead inventor, made by the Patent Office, is claimed as an important victory by the General Electric Company, and may develop another cause celebre in patent litigation.

Theory of the Transformer.*-III.†

BY F. BEDELL AND A. C. CREHORE.

INTRODUCTORY TO THE TRANSFORMER DIAGRAM.

The word "transformer," or "converter," in the language of the electrician, is used in a technical sense. To him the terms suggest an instrument used to change or to "transform" an electric current from one magnitude to another, or to change the potential of the current from one value to another; for, an increase in the potential usually implies a decrease in the current.

Most of the transformers which are in the market at the present day are *inductive* transformers, that is to say, they depend upon the principle, discovered by Faraday, that a current flowing in one coil can influence a second coil, which is entirely insulated from it, so as to set up a current in the second coil merely through the agency of the intervening medium.

If the current in the first coil, called the "*primary*," is a steady direct current, that is, flowing constantly in the same direction, then we shall see that it does not cause a current to flow in the second coil, called the "*secondary*," and has no influence upon it. It is only when the current in the primary is changing that a current is induced in the secondary, and, indeed, when the primary current is changing the most rapidly, the secondary current is a maximum. A transformer can only be used, therefore, upon a circuit having a variable current.

The office of the primary is to set up magnetic lines of induction in the surrounding medium, which continually change as the primary current changes. Some of these induced magnetic lines, which by their very nature always form closed curves, thread the secondary circuit, and, thus they keep constantly changing the induction through the secondary. Hence, by Faraday's law, according to which there is always an electromotive force in a circuit proportional to the rate of change of the magnetic induction through that circuit, there will be a variable electromotive force impressed upon the secondary.

To make the influence of the primary upon the secondary as great a possible, it is desirable to have as many primary

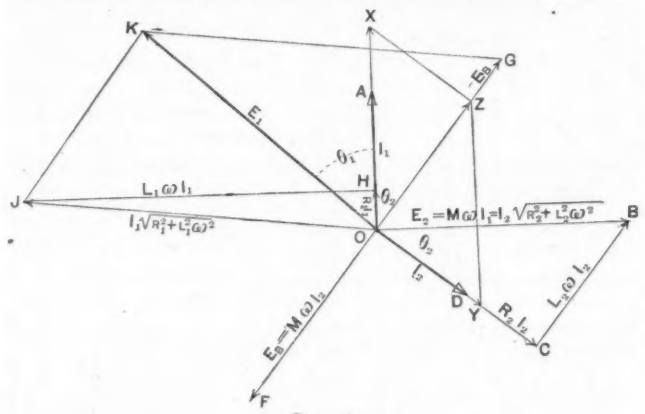


FIG. 4.

lines of induction thread the secondary as are found practicable. This requirement is usually met in practice by making the magnetic circuit of the best quality of iron, and making it of such a shape that there is little chance for the lines generated by the primary to avoid passing through the secondary. Moreover the magnetic reluctance is greatly reduced by making the magnetic circuit entirely closed and by having the length small while its cross-section is large. However, while the use of iron in the magnetic circuit proves of great advantage in increasing the induction, we shall find that there are objections to its use in too great quantities.

There is a loss of energy in the iron itself caused by the repeated reversal of its magnetism, which is known as the loss of energy due to "hysteresis." There is also a loss of energy in the iron, even when it is carefully laminated, due to the eddy currents, or "Foucault currents," as they are sometimes called, which are merely currents induced in the iron itself. The iron, being a good conductor of electricity, forms within its own body many little closed ircuits which act as secondary circuits, and allow electric currents to circulate around them and thus cause a loss of energy due to heating. The loss of energy due to Foucault currents may be minimized by careful lamination in the plane of the lines of force, but the hysteresis loss cannot thus be lessened.

Because the use of iron is in some ways such a great advantage in the transformer, and in others has its disadvantages, there have been many conflicting opinions advanced by men of the greatest scientific as well as practical ability, as to what the proper proportion between the iron and copper in a transformer should be. Perhaps as much literature has been written bearing upon this point as upon any other one thing concerning the transformer.

In the following discussion we shall consider that the variable electromotive force supplied to the primary of the transformer is an harmonic electromotive force. It can be shown that even when the electromotive force is not harmonic a transformer, designed under the supposition that it is so, generally gives a remarkably close approximation to what is desired. In an article in the "Electrical Engineer," Charles P. Steinmetz says concerning this subject: "The waves of all alternating dynamo-electric machines undermost any circumstances are either so nearly harmonic or sine-waves, that they can be considered as such without hesitation, or, even if they differ 'very considerably' in their shape from true sine waves, nevertheless, the assumption of sinusoidal shape generally gives a remarkably fair approximation." He further says: "For instance, in the Westinghouse transformer the primary current, especially for open secondary circuit, differs very considerably from an harmonic wave. Nevertheless, we shall see how closely the phenomena observed with this transformer are represented by the polar diagram of sine-waves."

The reason why the approximation can be made so closely is found in the fact that we may with scarcely any error substitute for a non-sinusoidal wave an equivalent sine-wave.

In the following discussion, therefore, we shall confine our attention to the case of an harmonic electromotive force impressed upon the primary.

THE TRANSFORMER DIAGRAM ESTABLISHED UPON AN ANALYTICAL BASIS.

When a unit current flows in the primary circuit the number of lines of induction threading the secondary due to this current is M, the coefficient of mutual induction of the two circuits, by definition. Accordingly a primary current i_1 produces Mi_1 lines of induction through the secondary. Now, by Faraday's law, the electromotive force impressed upon a circuit is equal to the rate of change of the induction through it (a decrease of the induction making a positive electromotive force); hence, if e_2 is the impressed electromotive force upon the secondary,

$$e_2 = -\frac{dN}{dt} = -\frac{d\,(Mi_1)}{dt} = -M\frac{di_1}{dt}, \qquad (18)$$

where N denotes the number of lines "threading" the secondary circuit, and is equal to the product of the number of secondary turns and the number of lines passing through the secondary coil as a whole. The subscripts 1 and 2, thus e_1, e_2, refer throughout this discussion to the primary and secondary circuits respectively. The small letters e and i denote instantaneous values, and the corresponding capital letters, E and I, maximum values of harmonic electromotive force and current, respectively.

If the electromotive force impressed upon the primary is harmonic, it will be found that the primary current is also harmonic and may be written,

$$i_1 = I_1 \sin \omega t, \qquad (19)$$

where ω is equal to $2\pi n$, that is 2π times the frequency. The time is here counted from the moment when the current is zero. By differentiation

$$\frac{di_1}{dt} = I_1 \omega \cos \omega t. \qquad (20)$$

Upon substituting this in equation (18) we have an expression for the electromotive force impressed upon the secondary; thus,

$$e_2 = -M\omega I_1 \cos \omega t = M\omega I_1 \sin\left\{\omega t - 90^\circ\right\}. \qquad (21)$$

This shows that the secondary impressed electromotive force lags 90 degrees behind the primary current, and is equal in magnitude to $M\omega$ times the primary current, that is, to $M\omega I_1$.

Referring to Fig. 4, draw a vector $\overline{O\,A}$ to represent the harmonic primary current given by equation (19). The lines represent maximum values. All diagrams are supposed to be revolving counter clockwise and instantaneous values are represented by the projection upon any fixed line of reference. Then 90 degrees behind $\overline{O\,A}$, in the negative or lag direction, draw the vector $\overline{O\,B}$ having a magnitude $M\omega I_1$. This represents, therefore, the electromotive force impressed upon the secondary circuit according to equation (21).

We may now regard this secondary impressed electromotive force as acting in a single circuit, whose total resistance is R_2, and self-induction L_2. For the present we will consider that this L_2 belongs entirely to the transformer, and that there is no external self-induction in the secondary circuit. It is easy to calculate the current which will flow in the secondary under these circumstances, considering it as a simple circuit.

If the electromotive force acting in a simple circuit in which there is resistance and self-induction is

$$e = E \sin \omega t, \qquad (22)$$

we know* that the current will be

$$i = \frac{E}{\sqrt{R^2 + L^2\omega^2}} \sin\left\{\omega t - \tan^{-1}\frac{L\omega}{R}\right\}. \qquad (23)$$

If the electromotive force is that impressed upon the secondary, as given in equation (21), the secondary current is

$$i_2 = \frac{M\omega I_1}{\sqrt{R_2^2 + L_2^2\omega^2}} \sin\left\{\omega t - 90^\circ - \tan^{-1}\frac{L_2\omega}{R_2}\right\} \qquad (24)$$

Referring to Fig. 4, we may now represent the secondary current by a vector $\overline{O\,D}$ whose magnitude is equal to the coefficient of the sine in equation (24), that is

$$I_2 = \frac{M\omega I_1}{\sqrt{R_2^2 + L_2^2\omega^2}}, \qquad (25)$$

lagging behind $\overline{O\,B}$ by an angle whose tangent is $\frac{L_2\omega}{R_2}$. By the graphical construction for simple circuits, above referred to, we know that the right triangle O C B upon $\overline{O\,B}$ as hypotenuse represents the secondary electromotive forces, $\overline{O\,C}$ that necessary to overcome the resistance, $\overline{C\,B}$ that necessary to overcome the self-induction, and $\overline{O\,B}$ the impressed electromotive force upon the secondary, which is the geometrical sum of the components $\overline{O\,C}$ and $\overline{C\,B}$.

The relation between the primary and secondary circuits is entirely a mutual one. A current flowing in the secondary must cause an electromotive force in the primary just as the primary causes one in the secondary. This electromotive force set up by the secondary current in the primary is usually called the "back" electromotive force. It may be found in exactly the same manner as is found the electromotive force impressed upon the secondary, due to the primary current. Thus, writing e_B for back electromotive force, we have

$$e_B = -\frac{d\,(M\,i_2)}{dt} = -M\frac{di_2}{dt}. \qquad (26)$$

Differentiating the expression for secondary current, equation (24), we have

$$\frac{di_2}{dt} = I_2\,\omega \cos\left\{\omega t - 90^\circ - \tan^{-1}\frac{L_2\,\omega}{R_2}\right\}. \qquad (27)$$

By substitution above in (26), we obtain the back electromotive force:

$$e_B = M\,\omega\,I_2 \sin\left\{\omega t - 180^\circ - \tan^{-1}\frac{L_2\,\omega}{R_2}\right\}. \qquad (28)$$

The back electromotive force accordingly is 90 degrees behind the secondary current, and has a maximum value, $M\,\omega\,I_2$.

In Fig. 4 we may now represent the back electromotive force by a vector $\overline{O\,F}$, 90 degrees behind the secondary current, $\overline{O\,D}$, and equal in magnitude to $M\,\omega\,I_2$.

Since we have assumed the primary current to be as given in equation (19), we are able to tell the secondary electromotive force, equation (21), the secondary current, equation (24), and the back electromotive force, equation (28). It now remains to find what primary electromotive force will be required to drive these currents. Instead of having but two electromotive forces to overcome, as it would have in the case of a simple circuit, the primary electromotive force must now not only overcome the electromotive force of resistance and of self-induction in the primary, but also the back electromotive force in the primary caused by the secondary.

The electromotive force to overcome the primary resistance always has the same direction as the primary current, and is equal to the primary current times its resistance; that is, denoting the instantaneous value of this component by e_{R_1}, we have

$$e_{R_1} = R_1\,i_1 = R_1\,I_1 \sin\,\omega\,t. \qquad (29)$$

The maximum value of this component is $R_1\ I$, and it is denoted in Fig. 4 by the vector $\overline{O\,H}$ in the direction of the primary current, and equal to the primary current multiplied by R_1.

The component of the primary electromotive force, necessary to overcome the primary self-induction, is equal and opposite to the electromotive force of self-induction, and is therefore 90 degrees ahead of the current (see "Alternating Currents," page 219), and is represented by the equation

$$e_{L_1} = L_1\,\omega\,I_1 \sin\left\{\omega\,t + 90^\circ\right\}. \qquad (30)$$

The maximum value of this component is $L_1\,\omega\,I_1$ and may be represented in Fig. 4 by the vector $\overline{H\,J}$, 90 degrees ahead of the primary current $\overline{O\,A}$. Indeed, the triangle O H J is the triangle of electromotive forces for the primary when no current is allowed to flow in the secondary, and the primary is considered as a simple circuit having resistance and self-induction. In this case the necessary impressed electromotive force upon the primary is $\overline{O\,J}$.

But when the secondary current is allowed to flow, the primary electromotive force must overcome the back electromotive force due to this secondary current. This electromotive force, to overcome the back electromotive force, must be equal and opposite to it and is represented, therefore, by equation (28) with the sign changed, that is,

$$-e_B = M\,\omega\,I_2 \sin\left\{\ t - \tan^{-1}\frac{L_2\,\omega}{R_2}\right\}. \qquad (31)$$

In Fig. 4, $\overline{O\,G}$, being equal and opposite to $\overline{O\,F}$, represents that component of the primary electromotive force necessary to overcome the back electromotive force.

Now, the primary electromotive force is easily found in the diagram, since it is the geometrical sum of the three components $\overline{O\,H}$, $\overline{H\,J}$, and $\overline{O\,G}$. The resultant of $\overline{O\,H}$ and $\overline{H\,J}$ gives $\overline{O\,J}$, and the resultant of $\overline{O\,J}$ and $\overline{O\,G}$ gives $\overline{O\,K}$, the required primary impressed electromotive force.

Analytically we may find this electromotive force by adding together the three components expressed in equations (29), (30) and (31). The sum of (29) and (30) gives

$$e_{R_1 L_1} = I_1\sqrt{R_1^2 + L_1^2\,\omega}\,\sin\left\{\omega t + \tan^{-1}\frac{L_1\,\omega}{R_1}\right\}. \qquad (32)$$

This is represented in the diagram by the line $\overline{O\,J}$. The sum of (32) and (31) gives the value of the required primary electromotive force,

$$e_1 = E_1 \sin\left\{\omega t + \theta_1\right\} \qquad (33)$$

where E_1 is the maximum primary E. M. F., equal to

$$\sqrt{I_1^2(R_1^2 + L_1^2\omega^2) + M^2\,\omega^2\,I_2^2 + \frac{2M\,\omega I_2 I_1 (R_1 R_2 - L_1 L_2 \omega^2)}{\sqrt{R_2^2 + L_2^2\,\omega^2}}} \qquad (34)$$

* All rights reserved.

† For previous sections of this article see THE ELECTRICAL WORLD, March 25, 1893, p. 223, and April 8, p. 261.

* For the analytical proof of this and its graphical representation the reader is referred to the book by the writers entitled "Alternating Currents," published by the W. J. Johnston Company, Ltd.

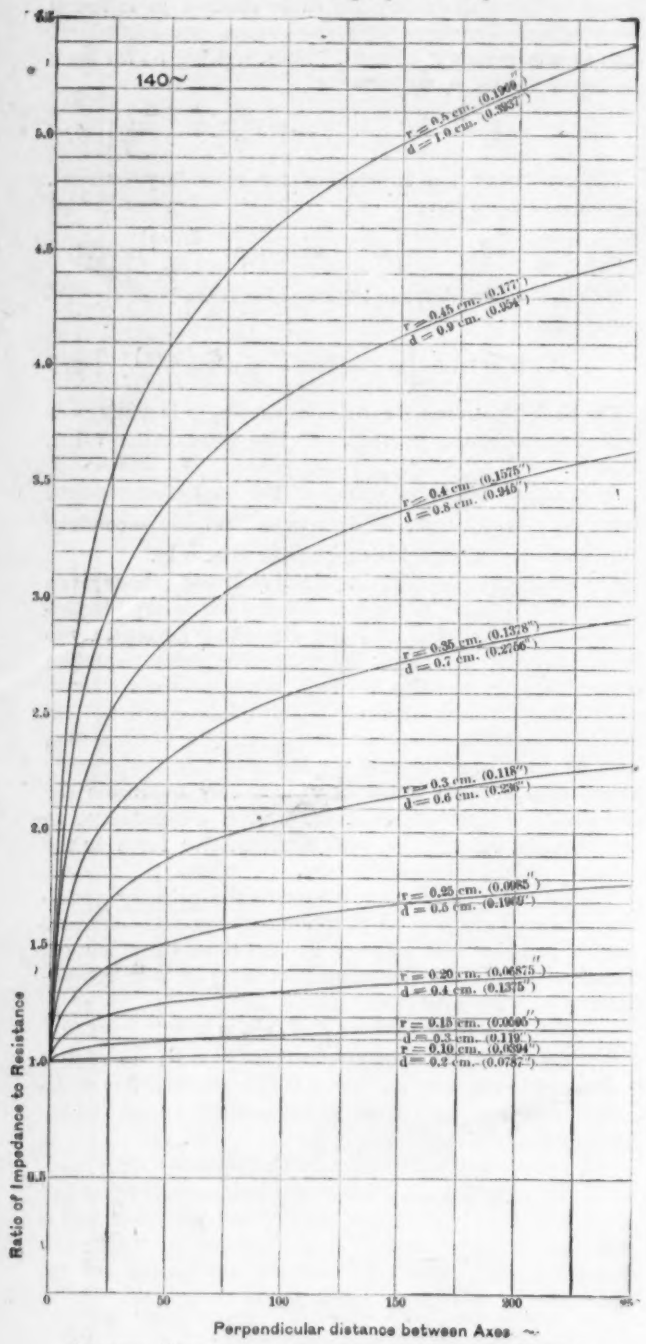
and tan $$\theta_1 = \frac{L_1 \omega I_1^2 - L_2 \omega I_2^2}{R_1 I_1^2 + R_2 I_2^2}. \quad (35$$

By means of equation (25) both (34) and (35) may be simplified and written

$$E_1 = R_1 I_1 \frac{R_2}{\sqrt{R_2^2 + L_2^2 \omega^2}} \sqrt{1 + \left(\frac{L_1 \omega}{R_1} + \frac{L_2 \omega}{R_2}\right)^2}$$

and

$$\tan \theta_1 = \frac{\frac{L_1 \omega}{R_1}}{1 + \frac{L_1 L_2 \omega^2}{R_1 R_2} + \frac{L_2^2 \omega^2}{R_2^2}}.$$



Curves Showing Impedance of Copper Wires.

If we put $$\frac{L_1 \omega}{R_1} = \tan \varphi$$

and $$\frac{L_2 \omega}{R_2} = \tan \theta_2,$$

we have

$$E_1 = R_1 I_1 \cos \theta_2 \sqrt{1 + (\tan \varphi + \tan \theta_2)^2} \quad (34a)$$

and

$$\tan \theta_1 = \frac{\tan \varphi}{\sec^2 \theta_2 + \tan \varphi \tan \theta_2}. \quad (35a)$$

These expressions may be verified from the geometry of the diagram. Usually the angle $H O J = \varphi$ is nearly a right angle, so that tan φ is large compared with tan θ_2. If we make this assumption we may easily write the approximate expressions derived from (34a) and (35a),

$$E_1 = R_1 I_1 \frac{\cos \theta_2}{\cos \varphi},$$

approximately and tan $\theta_1 = \cot \theta_2$, approximately.

Thus we have rigorously established the transformer diagram, Fig. 4, upon an analytical basis, and find that, if the impressed electromotive force is harmonic, the various currents and electromotive forces are harmonic, both in primary and secondary. All the actions of a transformer may be thus simply expressed by a geometrical diagram, and we will hereafter follow the graphical method, inasmuch as the analytical expressions in many cases become quite complicated.

THE RESULTANT MAGNETIZATION OF THE FIELD.

In a former paper we have seen that the magnetizing force $\mathfrak{h}$ is expressed by the equation

$$\mathfrak{h} = \frac{4 \pi S i}{10 l}, \quad (36)$$

when i is given in ampères. It is evident from this that, when the current i is a variable quantity, the magnetizing force varies always in proportion to i. This magnetizing force in the iron causes a number of lines of induction per square centimetre $\mathfrak{b}$ equal to μ times $\mathfrak{h}$, where μ denotes the permeability of the magnetic material. The magnetizing force is a rapidly varying quantity, and the induction changes in unison with it. The permeability μ varies with the degree of magnetization; but, unless the magnetization reaches a large value, the variation in μ is small and in the present discussion it is considered that the curve of magnetization is a straight line within the range of magnetization in which the transformer is used, so that μ is considered constant. Moreover, experience has shown that the time lag of the magnetization behind the magnetomotive force is inappreciably small in dealing with frequencies which it is customary to use in transformers. We may, then, with this understanding, write the value of the magnetization per square centimetre,

$$\mathfrak{b} = \mu \mathfrak{h} = \frac{4 \pi \mu S i}{10 l}. \quad (37)$$

The total induction in the iron at any moment is that due to the total number of ampère turns upon the iron circuit at that moment. In the transformer, when both a primary and secondary current are flowing at the same time, the total number of ampère turns is the sum of those due to the primary and those due to the secondary, and denoting the total ampère turns by S i we have

$$S i = S_1 i_1 + S_2 i_2, \quad (38)$$

and the resultant magnetization at that instant,

$$\mathfrak{b} = \frac{4 \pi \mu}{10 l} (S_1 i_1 + S_2 i_2). \quad (39)$$

We have already found expressions for the primary and secondary currents in equations (19) and (24) respectively, which are represented in the diagram by the lines $\overline{O A}$ and $\overline{O D}$.

Upon substituting the values of i_1 and i_2 in the expression $S_1 i_1 + S_2 i_2$, we have

$$S_1 i_1 + S_2 i_2 = S_1 I_1 \sin \omega t + S_2 I_2 \sin \left\{ \omega t - 90^\circ - \theta_2 \right\}. \quad (40)$$

In a previous paper the relations have been established between the coefficients of induction and the number of turns of wire, viz.:

$$\frac{S_1}{S_2} = \frac{L_1}{M} = \frac{M}{L_2} \quad (41)$$

The relation between the primary and secondary currents is readily obtained from Fig. 4, thus:

$$M \omega I_1 \sin \theta_2 = L_2 \omega I_2.$$

Hence, substituting the value for M, given in (41),

$$\frac{S_1 L_2}{S_2} \omega I_1 \sin \theta_2 = L_2 \omega I_2,$$

and $$S_1 I_1 \sin \theta_2 = S_2 I_2. \quad (42)$$

Substituting (42) in (40), we have

$$S i = S_1 i_1 + S_2 i_2 = S_1 I_1 \left\{ \sin \omega t - \sin \theta_2 \cos (\omega t - \theta_2) \right\}. \quad (43$$

Expanding cos $(\omega t - \theta_2)$ and reducing, we have

$$S i = S_1 i_1 + S_2 i_2 = S_1 I_1 \cos \theta_2 \sin (\omega t - \theta_2). \quad (44)$$

Hence, by (39) the instantaneous value of the induction per square centimetre is

$$\mathfrak{b} = \frac{4 \pi \mu}{10 l} S_1 I_1 \cos \theta_2 \sin (\omega t - \theta_2); \quad (45)$$

and the maximum value is

$$\mathfrak{B} = \frac{4 \pi \mu}{10 l} S_1 I_1 \cos \theta_2. \quad (46)$$

From (45) it is seen that the angle of lag of $\mathfrak{B}$ behind the primary current is θ_2, the same as the lag of the secondary current behind the impressed E. M. F. Hence the resultant magnetization is just 90 degrees in advance of the secondary current as it should be, since the magnetization is the cause of the secondary current, which is a maximum when the magnetization is changing most rapidly.

To represent the magnetization upon the diagram, Fig. 4, draw $\overline{O X}$ equal to $\frac{4 \pi \mu}{10 l} S_1 I_1$ and $\overline{O Y}$ equal to $\frac{4 \pi \mu}{10 l} S_2 I_2$ in the direction of the primary and secondary currents respectively. The resultant $\overline{O Z}$ represents the magnitude and direction of the resultant magnetization. It lags behind $\overline{O A}$ by an angle θ_2 and its magnitude corresponds to that given in equation (46).

(To be continued.)

Impedance.*

BY A. E. KENNELLY.

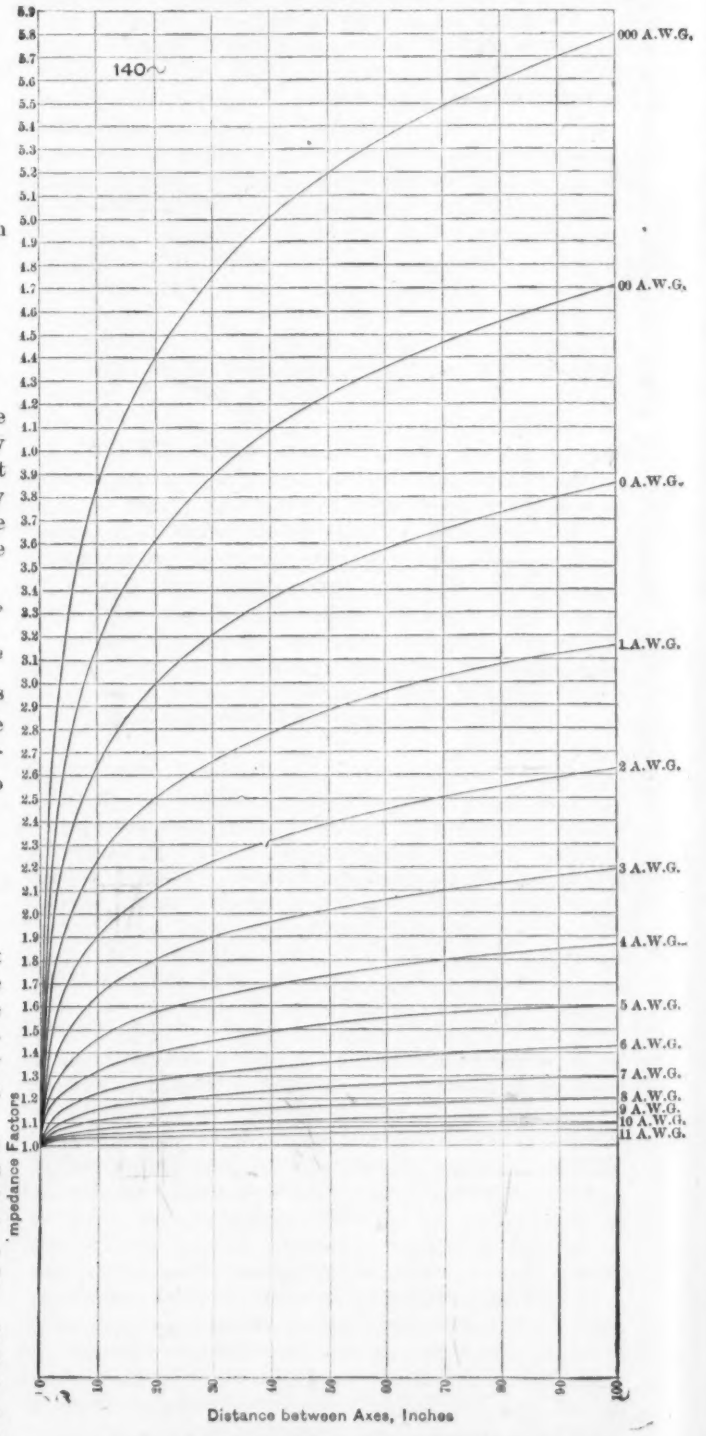
The impedance of a conductor is stated as its apparent resistance expressible in ohms, with the addition of the definition adopted at the Paris Congress of 1889, as the ratio of the E. M. F. to the current. Under this condition, if I denotes the impedance of a circuit, Ohm's law generalized becomes C = E, and then applies to both alternating and continuous currents.

The rules are then given for the geometrical and arithmetical combination of impedances. The formulas for arriving at these results have been obtained by Rayleigh, Fleming, Bedell, Crehore, and others, but they are here for the first time shown to be subject to all the usual rules of continuous current circuits. Examples of such cases are examined in detail.

The application of impedance principles to measuring instruments for alternating currents is next examined and two actual examples selected. Thus a particular Thomson wattmeter is quoted as having an armature circuit resistance of 455.5 ohms and an impedance of 456.0 ohms, so that this instrument indicates, owing to impedance, less on alternating than on continuous circuits by one-ninth of one per cent.

The impedance of copper wires suspended on poles in pairs is next considered, with its application to alternating current distribution of light and power. Tables have been computed whose results are shown in curve diagrams for direct inspection, and for the frequencies of 40~, 60~, 80~, 100~, 120~ and 140~. In these curves the impedance factors are found from the size of wires and their distance apart. Thus for a pair of No. 000 B. & S. wires employed as conductors for alternating current supply at 140~ and suspended 100 inches apart, the drop is shown to be nearly six times as great (5.8) as with the same strengths of continuous current. Such a size of wire and distance of separation would certainly be exceptional, but with common sizes and distances the impedance factors are often 1.5, representing drops of 50 per cent. in excess of what would be found with equal strengths of continuous current. The tables and curves are shown to apply to interior or secondary wiring as well as primary circuits, and to triphase conductors, when all three wires are equidistant. In order to determine the drop on such alternating current supply mains it is only necessary to ascertain the continuous current drop by the usual tables or by computation of resistance, and to then multiply this drop by the impedance factor taken from the curves for the frequency, size of wire, and distance employed.

The influence of current wave character is then taken into account. It is pointed out that the tables and curves only apply to pure sine waves for which the impedance factors are always minima. All departures of the current waves from the simply harmonic type give rise to increase in the drop, and augment the impedance factors. The augmentation can be computed when the shape of the current waves is known. A simple way to ascertain, therefore, whether current waves in a circuit are sinusoidal or not is to pass the current through such a pair of overhead wires, or through any choking coil of copper wire without iron core, having known resistance and inductance, consequently known (small) impedance for the frequency employed, and to compare the observed voltage across the terminals of the coil with the product of the impedance and current strength. If the current waves are approximately sinusoidal the observed and computed drops will approximate, but the greater their divergence the more marked the departure from the sinusoidal form.



Curves Showing Impedance of Copper Wires.

The impedance of iron wires is finally examined from an experimental point of view, and it is shown that the impedance, or apparent resistance to alternating currents, of a loop of iron wire is not constant, but depends

* Abstract of a paper read before the American Institute of Electrical Engineers, April 18, 1893.

upon the strength of the current it conveys. As the current strength increases, the impedance rises, attains a maximum, and then decreases again.

The mean inductance of small wires of iron suspended on poles, as in telephonic conductors, is shown to be experimentally about twelve millihenrys per mile more than if the wires were of copper.

Conductors and Insulators.—IV.

BY REGINALD A. FESSENDEN.

If we take a battery jar full of copper sulphate solution with two electrodes in it, and pass a current through it, we know that copper is deposited on one plate, and taken off from the other. To get a clear idea of what goes on, according to our theory, suppose the whole apparatus magnified many millions of times, and our personal "time constant" so much reduced that we could see the moving molecules, so magnified as they moved (instead of their appearing like slightly dark streaks, as they would otherwise, since they move at the rate of something in the neighborhood of a mile a second).

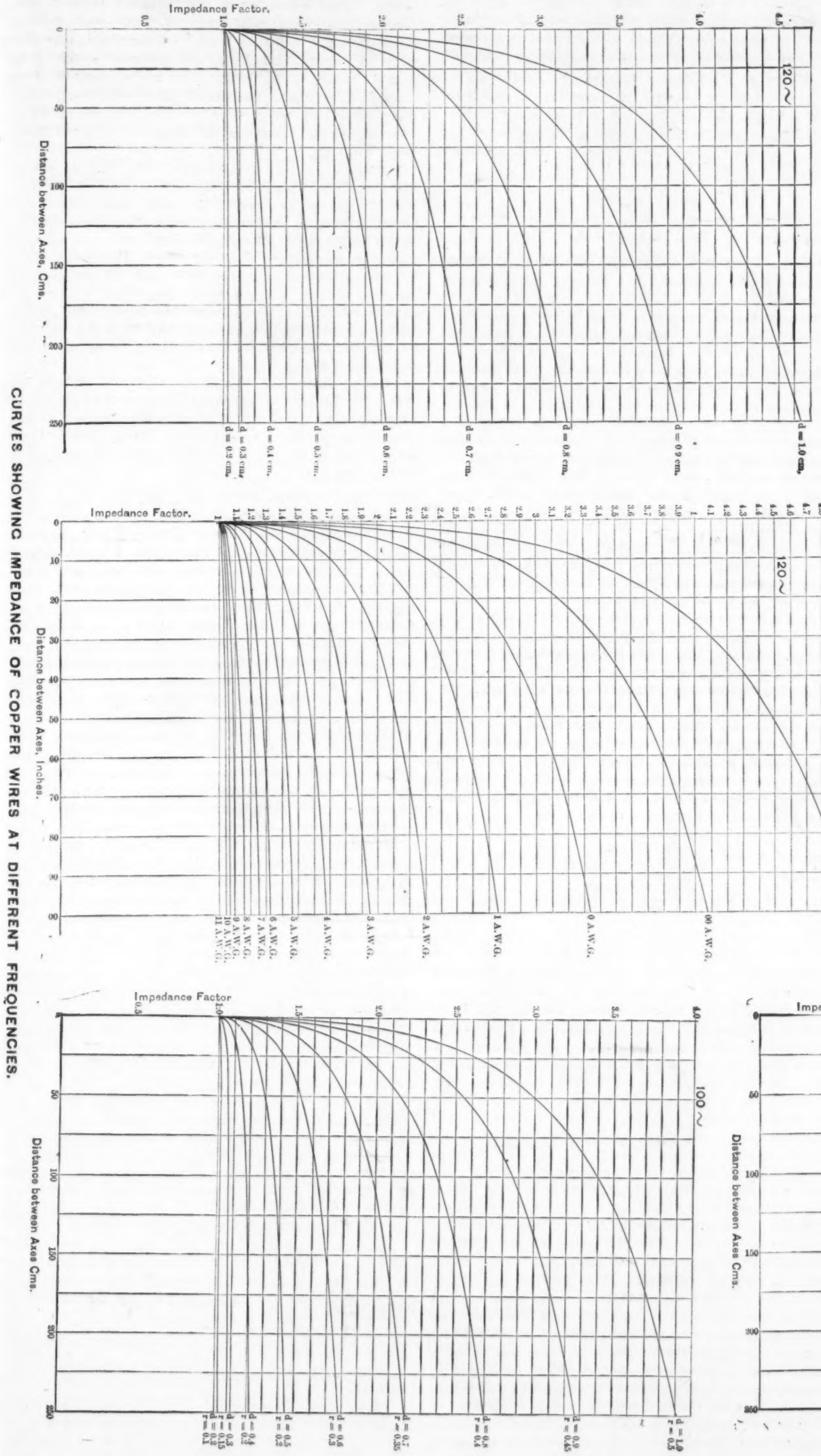
We should, according to our theory, see at first an immense number of bodies of different sizes, rolling and tumbling over each other as they collided, with almost incredible velocity. They would be seen to consist of several different kinds. The majority would be molecules of water, each molecule consisting of one atom of oxygen joined to two of hydrogen, but the thing joining them would not be seen, unless we had some means of seeing the ether also. As these invisible links hold the three atoms together pretty strongly, it is only occasionally that, on being bumped into by another molecule, the imparted kinetic energy would be so great as to cause the molecule to be broken up; and consequently there will be very few atoms of oxygen and hydrogen moving about singly in the fluid, and these will be continually taken up to form new molecules whenever a few such single atoms meet together.

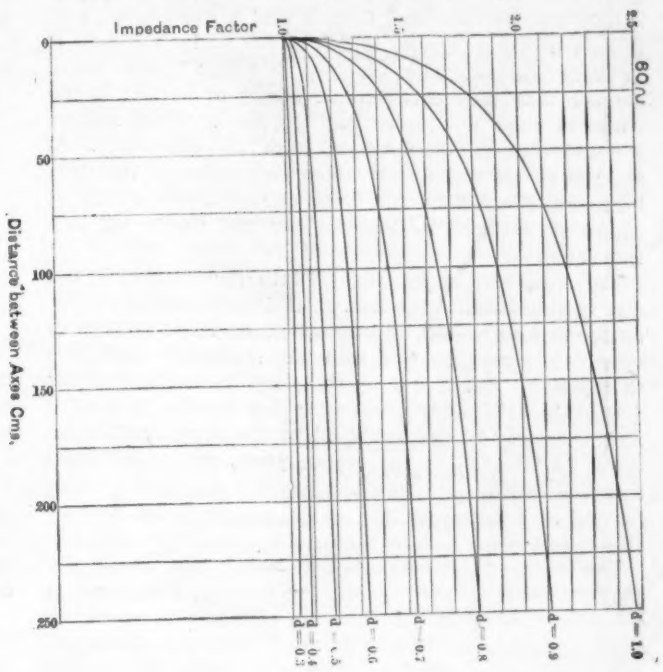
A second kind of molecules to be seen will be those of the copper sulphate. These will appear more complicated, consisting of one copper, one sulphur and four oxygen atoms. They are not bound together so strongly as the atoms of the water molecules are, and consequently they are being continually broken up by the constant colliding of the other atoms. The weakest bonds in the molecule are those joining the copper to the rest of the molecule, and consequently when it breaks up, it generally does so at that point, and we have a number of so-called free "ions" of copper, and of SO_4 always in the liquid. The four atoms of oxygen and one of sulphur which go to make up the SO_4 ion hold together pretty tightly, perhaps as tightly as the atoms which form a molecule of water do, and so this ion is not often broken up.

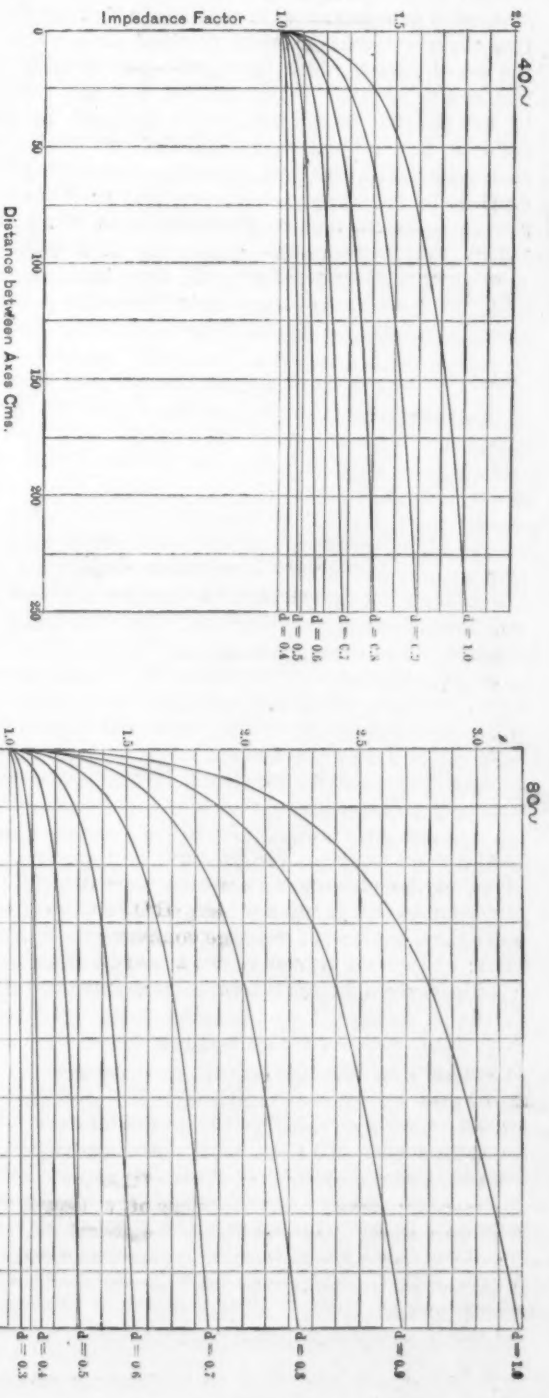
Thus in the centre of the liquid we find out of, say, 1,000,000 of the bodies observed, 990,000 are molecules of water, 9,000 are molecules of copper sulphate, 490 are ions of copper, 490 are ions of SO_4 and the remaining 20 are disassociated atoms of hydrogen, oxygen and sulphur, formed from a few broken up molecules of water and ions of SO_4.

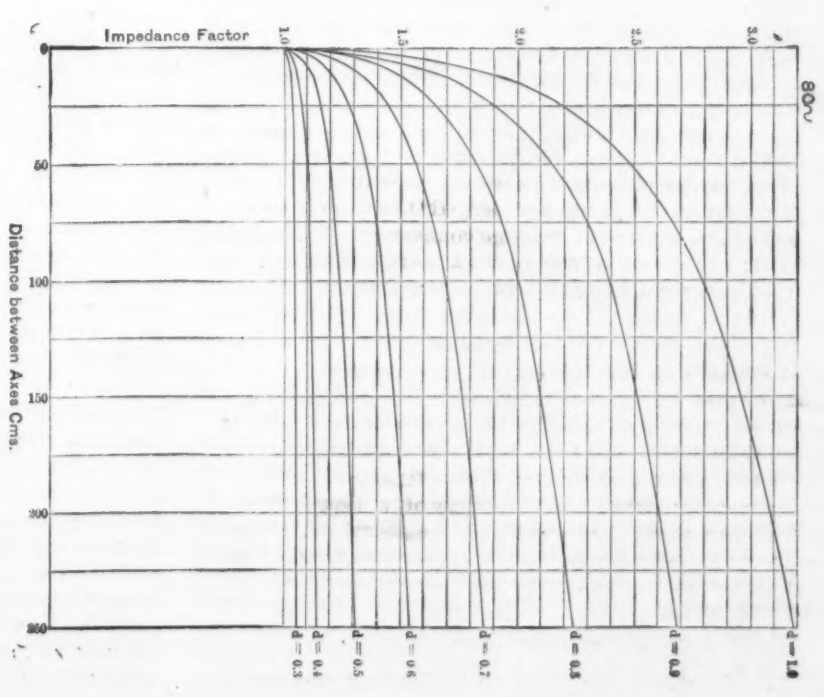
On the surfaces of the fluid, where it touches the glass, the ordinary equations for the motions of colliding bodies do not hold, on account of the attraction which the glass has for the bodies which make up the fluid, and the latter is probably denser there than elsewhere,

CURVES SHOWING IMPEDANCE OF COPPER WIRES AT DIFFERENT FREQUENCIES.









and does not behave exactly like a fluid. On the surface of the liquid we shall see, every now and then, a molecule battered so violently that it is driven up in the air. If it has got an impetus of above a certain amount, it is driven quite outside of the reach of the attraction of the other molecules, and is evaporated. Otherwise it falls back again. In the fluid are two large masses of atoms, rather closer together than those which form the body of the fluid, and therefore held together more firmly. The atoms composing these masses behave differently from those of the fluid, for instead of tumbling one over the other and sliding in and taking one another's places when they collide, they simply vibrate back and forth round a fixed point, and though occasionally one is driven out of its position, it is very seldom. The distance between them being smaller than that between the atoms of a fluid is the cause of their not interchanging places. These masses are the copper plates which form the electrodes. In spite of the firmness with which they are held together, however, every now and then one of these atoms of copper is battered by its neighbor and passes off into the liquid.

The reason of its passing off into the solution is not due to the shock it received from its companion atoms, alone, as that would be insufficient by itself (except in very rare cases), to overcome the attractive force due to cohesion. But if it happens to receive a violent blow just at the time that a negative ion of SO_4 is near it and attracting it, the combined push and pull will overcome its cohesion to the copper plate, and it will pass away, as stated, into the solution as a molecule of $Cu\,SO_4$, leaving its negative charge on the copper plate, its positive charge being held by the negative one of the SO_4 ion.

The result of this action is that before long the copper plates would become lighter and smaller, and charged negatively, were it not that the converse phenomenon is always going on. Every now and then, one of the copper ions in the solution, coming too near the copper plate, and within the range of the cohesive force, is attracted to the plate, and becomes a part of it. As the attraction of cohesion is in this case aided by the negative charge which the plate received as a whole when the other atoms, which have gone into solution, left it, and as this negative charge will be promptly neutralized by the positive charge brought to the plate by the copper ions, it is evident that a state of equilibrium will be soon established, in which as many atoms are gained as are lost by the copper electrodes, and their weight will remain constant, and they will have no charge on the whole. But suppose one plate were at a higher level than another, then gravity would come into play and we might suppose that on the whole the lower plate would grow in weight, as, while there is an equal probability

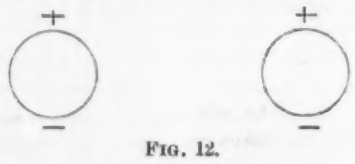


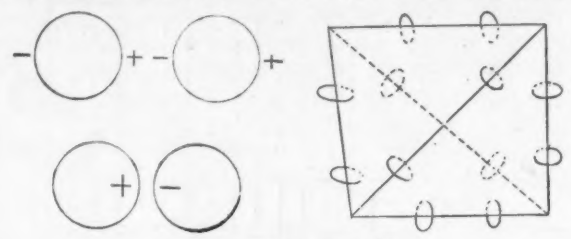
Fig. 12.

of the atom being driven off from either plate, there is a greater probability of its being deposited on the lower than on the higher. Consequently, on putting two copper plates one above the other, in a copper sulphate solution, and joining them through a galvanometer, we might expect to see a deflection on the instrument. Though the writer has looked for this in vain (with very crude apparatus, however), other observers have claimed to have noticed it. It is very difficult to answer the question decisively, however, as there are so many other things which would produce similar effects, such as slight differences in concentration or in temperature between the top and bottom. The charge given to the electrodes in the manner described above must be carefully distinguished from the charge received due to contact electricity. This will be spoken of later; at present it will be sufficient to point out that a copper plate immersed in copper sulphate alone receives no charge; it is only when some third substance is present, such as air or another metal, that a charge is received by the plate.

We will postulate that the attraction which holds the atoms together into molecules and the molecules together to form bodies with definitely fixed boundaries, is an electrostatic attraction. Reasons for this belief will be given later. Atoms not chemically combined may be supposed to have the surface integral of the electricity on them equal to zero. This may come about in two ways. Either they may actually have no electrical charges on any part of their surface, or they may have an equal quantity of the two kinds. We will take the latter alternative.

In either case the effect on bodies at a distance will be the same, i. e., zero. But for bodies nearby the case will be different, if we suppose with Prof. Lodge that there is an absolute unit of electricity, and that it is of such dimensions a single atom can only carry one or two such charges. For consider Fig. 12. There we have two similar and similarly charged atoms at a distance, and it will be seen that they will not attract each other. In Fig. 13 they have been brought close to each other. As they were being brought together, at a certain distance apart, the system became unstable, and either the charges moved on the surfaces of the atoms, or, what is more probable, the atoms themselves moved, with the result, as shown in the figure, that they now attract each other. This we may suppose to be the ordinary cohesive attraction which holds together the atoms of a copper plate. Suppose, however, that the atoms in Fig. 13 had been short circuited by some third substance, then the result as is shown in Fig. 14, where the attraction is still there, but is of a different nature and strength from that shown in Fig. 13.

Fig. 14 may be supposed to represent a chemical combination, and it is evident that if we separate them we will have two ions, or singly charged atoms. It does not matter, of course, how we do this, and so we see that when one of the molecules of copper sulphate is broken



Figs. 13, 14 and 15.

up, we shall get two electrically charged ions, one of copper, charged positively, the other of SO_4 charged negatively.

(The atoms of the metals have on the whole a greater attraction for positive charges then the atoms of the metalloids. Why this should be we do not know. An explanation which will do to hinge our ideas on temporarily may, however, be given as follows: Suppose our carbon atom as before to be as shown in Fig. 15, consisting of 12 vortex rings, three at each corner of a tetrahedron, and the direction of rotation of the vortex rings such that the inside of each ring moves from the centre of the line joining the two solid angles between which it lies toward the nearest solid angle. Then suppose that a vortex ring in the ether were capable of exerting a pressure in the same direction as a vortex ring does in air. Then we would have a resultant pressure at each solid angle of the atom, from the atom into space. This would correspond to a negative charge at each of the angles of the same amount, i. e., there would be four negative charges on the atom. If the vortex rings were rotating the other way the charges would be positive. Similarly, if we fall back on the idea given in chapter I. that the atoms may be formed of vortex rings arranged into different kinds of space nets, with the direction of rotation of the vortex rings such as will make these combinations dynamically stable, the chances are even that we shall have as many arranged so that the resultant pressure is directed outward as inward, i. e., as many negative as positive atoms. This illustration is, however, only mentioned for the sake of giving a little more definiteness to our ideas.)

(To be continued.)

An Inventor's Misgivings.

The following communication, which was recently received, needs no comment:

"As a reader of The Electrical World I beg to apply through its columns for some advice. I have invented an electric lamp on entirely new principles, and having applied for a patent the question is, what to do next. If my patent is allowed and issued, how long will it be before a Reis, a Drawbaugh, an Edison or a Goebel will claim to have made the same thing 'long, long ago'? I read a few days ago what purported to be an interview with Mr. Edison. A new electrical invention, just patented, was shown to him. 'Oh yes,' he said, 'I made that as far back as '72.' I exhibited a "renewed lamp" for which I have patents, to the president of one of the largest incandescent lamp companies. He asked, 'Have you shown this to Mr. ——?' naming the president of another lamp company. I replied, 'I have not.' Well, he said, 'If you do he will make a sketch of it, date it back five years and swear to it.' A recent learned professor has stated, 'There is not a single electrical principle in use that was not known years ago,' and I expect to read, almost any day, how Prof. V. Leoret, unwrapping a mummy, will find on parchment an account with illustrations of how the firefly was invented; then a detailed account of how some poor devil of an inventor brought out the glowworm; and to cap the whole, a minute description of some device which, being pushed down into the earth or hoisted into the air, will collect and supply all the electricity needed for heat, power and light; and we shall all want to know, as did the congressman, 'Where are we at?' That would go ahead of digging out the jars of fruit at Pompeii. You know too that Solomon said there was nothing new under the sun; but his was another case of 'big head.' I think sometimes that, being an old man, wealth is not of much account, and perhaps I had better (if my patent is granted) make a present of the invention to the public. If I go from here to the one place, it might add a star or two to my crown; or if, unfortunately for me, I find myself in a warm climate, I might in consideration of my gift be allowed a cool corner in which 'to think it over.'"

THE ELECTRICAL WORLD'S DIGEST

OF

Current Technical Electrical Literature.

(Compiled from the principal foreign electrical journals.)

BY CARL HERING.

ELECTRO-PHYSICS.

Work Done by Heated Wires.—Under the head of "Thermo Galvanometers," Mr. Carter, in the Lond. "Electrician," gives a solution of the following problem, proposed by that journal some time ago. Two equal wires are hung vertically, one with a pound weight and the other with an ounce weight attached; the same current is passed through both, heating them and causing them to expand; on stopping the current they contract, raising their respective weights; what are the changes in temperature and resistance and does one wire really do more work than the other?

Initial Capacity of Polarization.—Mr. Bouty, before the French Academy of Science (see "L'Ind. Elec.," April 10, pages 167 and 169), describes the results of experiments under various conditions. For the polarization p he gives the following formula:

$$p = \frac{C\,I\,t}{1 + B\,t}$$

in which C is the initial capacity of polarization, I the initial current strength, t the time and B a coefficient nearly independent of I characterizing the speed of the depolarization.

Striking Distances.—The Electrical World of Feb. 11, under the heading of "Striking Distances," contains the abstract of an article by Dr. Heydweiller; this article has since been translated and abstracted in the Lond. "Electrician," April 14, and is accompanied by an illustration of the apparatus.

UNITS, MEASUREMENTS, INSTRUMENTS, ETC.

Wattmeter.—In the "Elek. Zeitschrift," April 14, Mr. Friese describes a new form of laboratory wattmeter for small currents, intended to be used as a mirror instrument. The article is of considerable length and gives detailed information about the instrument and tests made to determine its properties; the apparatus itself is fully illustrated and all its constants are given. He reviews the necessary conditions of an accurate wattmeter and shows how they are met in this instrument. It consists essentially of a fixed coil and a light rectangular movable coil of fine wire surrounding and inclosing the fixed coil; the movable coil is suspended like in a d'Arsonval galvanometer by means of two long wires, one at the top and one at the bottom, the lower one being connected to its support through a small spiral spring; the coils are made of nickeline, which requires no temperature correction; the damping, which is said to make it absolutely aperiodic, is produced by a flat aluminium wire moving in paraffine oil. As the resistance is high compared with the self-induction, the determination of the latter becomes very difficult, and he, therefore, measured it by winding two coils of exactly the same form as those in the instrument, but of very many more turns; the self-induction of these were measured and that of the wattmeter coils was calculated from this under the assumption that the self-induction coefficient varies with the area of the mean winding and with the square of the number of windings; he thus finds that the apparent resistance differs from the true resistance by an absolutely inappreciably small amount. To determine whether the currents in one coil induce currents in the other, the movable coil was set at an angle to the other, was short-circuited and an alternating current sent through the fixed coil, when it was noticed that there was no appreciable deflection. He checks this experimental determination by calculating the induction in the movable coil from a current in the fixed coil, under the most unfavorable circumstances, and finds the number of volts generated are inappreciable compared with those normally used in the instrument.

Meter.—The new ampere hour meter of the firm of Siemens and Halske is fully illustrated in the "Elek. Echo," April 1. It consists essentially of a simple form of amperemeter having a pointer, the indications of which may be seen through a glass plate at any time; every 2½ minutes a 30-day clock brings a lever against the needle, registering the distance it has to travel, which is proportional to the current as indicated by the pointer.

Photographic Registering.—Dr. Raps, before a German society, illustrated a recording voltmeter in which the needle moved (transversely?) over an illuminated slit, which slit was periodically photographed on a sensitized paper by a clockwork mechanism.

Probable Value of the Ohm.—Mr. Dorn in a German report compiles the various determinations of the ohm made since 1884, giving them a weight of one or two; from 15 different determinations he obtains a general mean of 1.06280; the value of 1.063 would therefore be very nearly this value, differing only two-hundredths of one per cent.

Portable Photometer.—In a paper by Sir David Salo-

mon before the Institution of Electrical Engineers, reprinted in full in the Lond. "Elec. Rev.," he describes a photometer consisting essentially of two tubes, similar in appearance to an opera glass, each containing a pair of nicol prisms; a standard candle contained in a vertically suspended tube in front of one of these tubes serves as a standard; to measure a light the operator looks through both tubes and instead of varying the distances between the instruments and the light he revolves one of the prisms until the illumination in the two tubes is the same; from the amount by which the prism is to be revolved to produce a balance, the intensity of the unknown light is calculated. The whole photometer packed in a case is not much larger than a field glass. (Although interesting it is doubtful whether the instrument will prove very successful in practice; it is very doubtful whether a standard candle can be relied upon under those conditions, and it is likely that a number of errors would arise in the use of the instrument.) The discussion following the paper was not favorable.

DYNAMOS, MOTORS AND TRANSFORMERS.

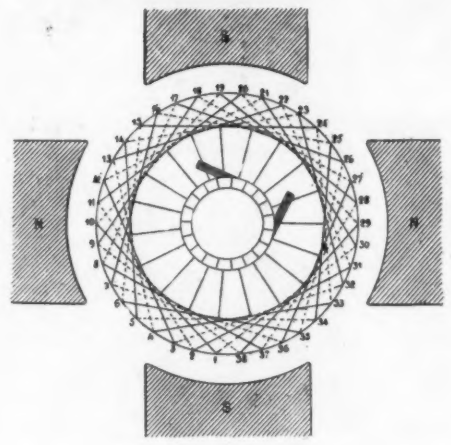
Alternate Current Motors.—Mr. Snell read a paper before the Institution of Electrical Engineers on "The Distribution of Power by Alternate Current Motors," the first part of which is given in full in the Lond. "Elect. Eng.," April 14. The object of the paper is to discuss the various alternate current motors in the market. It contains a very good short summary of the subject. Single phase synchronous motors, he says, are practically limited to a single pair of machines, in which the starting of the motor by auxiliary power is not a prohibitive objection. He enumerates the well known peculiarities of such motors, among which he states, that the current lags behind the pressure by an angle which is a maximum when the motor is not loaded, and there may then be a large idle current, which, though not representing much energy, causes a serious loss in the supply mains and in the generator; they must be designed and used for a single frequency; when excited by a direct or single phase alternating current, they have dead points in each period. The earliest attempt to meet these conditions was by laminating the field magnets of an ordinary direct current motor, but the results were not successful, as with shunt windings it was found practically impossible to excite the magnets, except with few turns of wire and large currents, and even then, owing to the difference of phase between the field and the armature currents, the torque is insignificantly small, and the dead points involve difficulties; a series winding is better, but is also useless, and the weight output is still very small; the loss by hysteresis alone is prohibitive, and the frequency would have to be reduced to about 20, which would render the current useless for lighting, and would increase the difficulty from dead points; from experiments he finds that the eye could easily detect 30 periods, and he therefore thinks that nothing less than 40 or 45 should be used. Another method involves a transformer principle, but it is applicable only to small machines; the motor is like a direct current motor, but has laminated fields, which are wound with two windings, one coupled to the supply mains and the other to the armature terminals, thus forming a secondary circuit; such motors give considerable torque, are self-starting, and have a probable efficiency of 60 degrees for 1-h. p. machines; the dead points are not very apparent, but the chief difficulties are that the number of lines of force in the two circuits is not the same, that there is considerable lag between current and the voltage, and that the primary and secondary currents are not in phase; with few turns per coil on the armature, the sparking is small, the best results being obtained when the axis of the armature field is 90 degrees from the other; it is an advantage to wind the armature with two circuits, so as to avoid short-circuiting the coils by the brushes.

Another step is to balance the self-induction of the shunt field by a condenser in series with it; if correctly proportioned, its E. M. F. will be equal and opposite to the counter E. M. F. of the magnets, the voltage and the field current will be in phase; the armature current will be equal in phase, and the maximum magnetization in the field and armature will occur nearly simultaneously. Owing to the armature reactions, the condenser will in practice probably not balance the counter E. M. F. at all loads; the motor could be used for only one frequency. In series wound motors the condensers are coupled in shunt to the field, but the objections are the same. High voltages may occur at the field terminals, owing to the fluctuations in the current; this can be obviated by arranging the condenser and the winding in sections, but it is open to objections. He then mentions the Stanley and Kelly motor, which has already been described in The Electrical World; he claims that it has the disadvantage of raising the interpolar resistance, and is likely to cause serious distortion in the main field. It has also been proposed to supply the idle currents by condensers across the mains.

He describes the split current rotary field motors, in which a two-phase current is split into two currents having a phase difference of 90 degrees. (They have been described in these columns.) He considers this a marked advance, but as being still far from perfect, for, owing to the armature reaction, the currents will not be self-adjusting for varying loads, and the output will therefore probably be less than that of the Tesla motor. He mentions the Stanley and Kelly motor, in which a secondary battery is used (which has also been described in these columns).

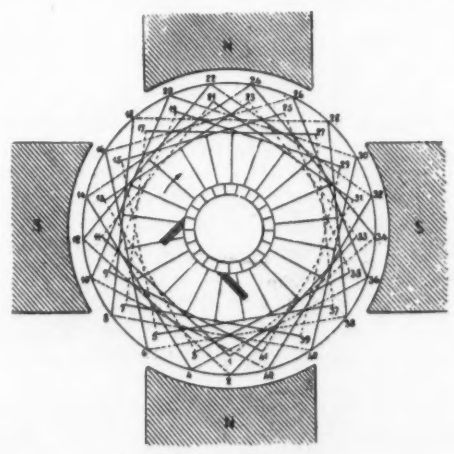
He gives a brief description of the multiphase motors, saying that while they offer no real advantage for mere transmission, they do so for distribution. He discusses at some length the pulsation of the field, about which there has been so much discussion. (This was fully explained in The Electrical World, Sept. 19, 1891, p. 194.) The armature reactions will be a maximum at starting, and will decrease as the speed decreases; they tend to weaken the resulting field and to diminish the torque.

Armature Windings.—The serial by Mr. Rechniewski in "L'Electricien," mentioned before in these columns, is continued in the issue of April 1. In the present portion he discusses cylinder and disc windings for multipolar machines; it is fully illustrated, with 8 diagramatic windings, most of which explain themselves; as most of



ARMATURE WINDING.

them have all been described before, only two will be reproduced here. All that applies to bipolar cylinder armatures applies equally well to multipolar armatures; if in the 4-pole machines, a coil occupies one-quarter of the circumference, the reaction of the armature will be a maximum and equal to that of a corresponding ring armature, but if it occupies only the area covered by the pole piece, the reaction will be a minimum. Instead of the whole coil being in one pair of fields, it can be made up of several coils, one in each pair of fields, connected in series. This winding is illustrated; every coil in this case, for a 4-pole machine, includes 4 portions of active wire; the windings in that case should be distributed uniformly and placed side by side, and not over each other; the number of sections in that case must be $4\ (4\,n \pm 1)$; for a 4-pole machine, or $p\ (p\,n \pm 1)$ for p poles: instead of one layer, several may evidently be used: This winding leads to the so-called zig-zag or wave winding; in this, the distances along the periphery between each of the parallel



ARMATURE WINDING.

parts of the coils are equal, as in an ordinary zig-zag of parallel lines, the circumferential angle between them being slightly greater or less than 90 degrees (for a 4-pole machine) in order that by continuing the winding repeatedly over the periphery a continuous and regular winding covering the whole armature is produced; the number of divisions is represented by $2\,(4\,n \pm 1)$, and the number of sections by $4\,n \pm 1$; the commencement of every section may be connected to a commutator bar, in which case two brushes will suffice without cross connectors, as the winding itself takes the place of such a connector; two layers instead of one may be used, in which case the number of divisions will be half of that in the preceding case, while the number of commutator sections remain the same; both these windings are illustrated in the accompanying figures. In large machines, in which bars are used instead of wires, the end connections may be made perfectly symmetrical and the armature winding may therefore be built up entirely of uniform pieces properly connected; this winding is also illustrated in the article. A disc armature winding may be supposed to be merely a cylinder winding, in which the diameter at one end has become smaller and smaller, and that at the other end larger and larger, making a cone instead of a cylinder and finally becoming a flat disc or ring; in practice, however, the difference between the two involves great difference in their construction, one of the principal being that disc armatures usually have no iron core, and the windings must therefore be self-sustaining. He describes and illustrates the well known Desroziers disc armature, which is perhaps one of the most extended in use at present; he also shows a diagram of the well known Fritsche armature, made up of straight diagonal conductors sufficiently rigid to make a self-sustaining armature.

Dynamos.—Mr. Snell continues his serial in the Lond. "Electrician" on "Electricity as a Motive Power;" the present installment is devoted to the designing of armatures and field magnets. It is written in the style of a text-book for amateurs, and must be read in its entirety.

ARC AND INCANDESCENT LIGHTS.

Blackening of Incandescent Light Bulbs.—Mr. Blainville does not believe that the blackening is due to the mercury used in the pumps, but believes it to be due to a small quantity of oxygen, forming carbonic oxide, which, when in contact with a relatively cold bulb, again decomposes, depositing its carbon, after which it again attacks the filament, producing more carbonic oxide, which is again decomposed, and so on. This deposit will form more rapidly in the beginning, as the bulb is colder. After a deposit has been formed the globe will become warmer and the deposit will be less rapid.

TRANSMISSION OF POWER.

Workshop Motors.—Mr. Sartiaux, in the workshop of a French railroad company, in which electric motors are used, publishes in a French journal the results of some tests to determine the power required to drive various machines, of which the following may be of interest:

The voltage used was from 115 to 118; the current required to drive various machines was as follows:

	Running empty.	Running loaded.
Large lathe	2.5 amp.	5 to 6 amp.
Medium sized lathe	6 "	10 to 12 "
Small lathe	3.5 "	5 to 6 "
Lathe for precise work	5 "	8 "
Jewelers' lathe	2.5 "	4 "
Small polishing lathe	3 "	5 "
Small drill-press	2.5 "	4 "
Large radial drill-press	3 "	7 "
Large drill-press	4 "	8 "
Medium drill-press	4 "	6 "
Milling machine	11.4 "	15 "
Grindstone	4 "	7 "
Band saw	8 "	9.5 "
Ventilator	7 "	8 "
Crushing and mixing machine	10 "	11 "

From this the horse power is readily calculated. It is interesting to note how little extra power is required to drive them loaded, over that required when running empty. The current used in the workshop, supplied from a central station, now costs them 4.18 francs per day, or together with incidental expenses for the electric motors, 5.18 francs per day. Formerly a gas engine was used, the cost of which was 13 francs a day besides the wages of a man to run the gas engine.

Belting.—In the conclusion of Mr. Mavor's article, in the Lond. "Elec. Eng.," he states among other things that the belt is not the only thing to be considered, but that the pulley also plays an important part; this should be as large in diameter as possible; 3,000 feet per minute is an easy speed, while they will run well at a mile a minute; the arc of contact should be as large as possible; the pulley should be flat, not crowned, as the latter involves transverse strains in the belt; the pulleys should not be too far apart, they should be smooth on the face, as a rough pulley tears the surface of the belt; they should be well centred and balanced; it is an advantage to cover them with leather, as the friction is thereby increased; the centre line should be horizontal in preference to vertical; the slack belt should be uppermost; a good leather belt needs no treatment and all substances like resin are fatal as they rapidly destroy the belt.

RAILWAYS.

Heilmann Electric Locomotive.—"L'Electricien," March 25, contains a short description, accompanied by nine large cuts, of the Heilmann electric locomotive as it is at present being constructed in France. This locomotive contains a steam boiler, steam engine, dynamo and 8 motors, one on each wheel axle. The object is to attain great speed with greater security and less wear and tear of the roadway, and also to serve as a step toward the introduction of his original idea of having motors on every axle of the whole train instead of on those of the locomotive only; the present locomotive is designed only for motors on its own axles, and it can therefore be used and tried on existing roads; his first intention was to use polyphase currents, but this has been abandoned for the present. The locomotive has a total length of 52.5 feet and is mounted on 2 bogie trucks, each having 4 axles; the steam engine is of the compound high speed type, and is mounted transversely; in addition there is a small engine and dynamo of 20 h. p. used as an exciter, and at the same time to supply light for the train. The locomotive is intended to replace one of 500 h. p. and is capable of giving from 600 to 800 h. p.; the total weight is 42 tons, the boiler weighing 20, the steam engine 5, the dynamos (and motors?) 11, coal (and water?) 6. The steam engine is of the compound, high speed type, is mounted transversely to the axles, and makes from 300 to 500 revolutions; the generator is of the 6-pole Gramme ring type, the diameter of the armature being about 4 feet, and its capacity 1,025 amperes and 400 volts at 300 revolutions; the motors

have 4 poles, but only 2 field coils, they are gearless and are coupled to one of the wheels by a coupling made of "woodite;" the diameter of the armature is about 26 inches; one of the wheels is removable, enabling the motor to be taken off for repairs; the diameter of the driving wheels is about 45 inches; the speed is to be 72 miles an hour when the motors make 560 revolutions; the motors are series wound, which is said to be an important point, as it admits of varying the velocity independently of the speed of the generator; this permits mounting grades more slowly, while the steam engine is running under favorable conditions.

INSTALLATIONS, CENTRAL STATIONS, ETC.

Champs-Elysees Station.—"L'Ind. Elec.," April 10, describes at some length this new station, which covers a very important area of the city of Paris. It is of interest, as it includes an area containing some of the most important dwellings, which are at some distance from each other, the consumption in many of them being cut off during considerable portions of the year. Alternating currents of 3,000 volts are used, each dynamo having a capacity of 400 kilowatts, the frequency is 40 and the secondary circuits have 100 volts; the 80 dynamos are exceptionally large in diameter, 19 feet, and are run at a speed of only 60 revolutions. The description is very complete, gives much detailed data and numerous well selected illustrations, including those of the dynamos, switchboard, and numerous cuts of the underground circuits. This is one of the most interesting stations in Paris, as it probably represents the latest alternating current practice in that country.

Central Station at Cassel.—The "Elek. Zeitschrift," April 14, gives some detailed data about the cost of installation and operation of the Cassel accumulator station.

Three-phase Installation.—The central station at Heilbron in which three-phase currents are used, is reported to be a success both from a practical and a financial standpoint; the consumption of light and power was doubled at the end of last year, when there were 1,900 incandescent lamps of 16 c. p., 22 arc lamps and 31 h. p. in motors. Demands for 3,600 incandescent lamps were recently made.

Train Lighting.—The arrangements used by the Northern Railway Company, of France, are illustrated and described briefly in "L'Electricien," March 25. There are three lamps of 8 c. p. of 30 volts in every car, intended to burn 30 hours; 16 cells are required, weighing .75 pound per candle per hour; they are placed in receptacles below the floor of the car; the cells are recharged without removing them from the car; the switches are arranged at each of two diagonal corners of the car so that in any case they can be operated from one side of the train; the batteries are recharged every day no matter how much they have been used, the capacity being sufficient for the longest service required. In a Swiss railway a simple meter, consisting of a cheap clockwork, which is started and stopped by the current, is used to show to what extent the cells have been discharged.

Steam Engine Trials.—The Lond. "Electrician" reprints an abstract of a paper by the late Mr. Willans.

WIRES AND WIRING.

Parallel Distribution.—The article by Mr. Jehl, mentioned last week, is concluded in the Lond. "Electrician," April 14. He discusses the subject of the variation in the loss in volts and finds that it is the same in the direct system as in the double loop system, and the same in the feeder as in the single loop system; if in the former two it is represented by v in the latter two it would be represented by ⅜ v. He also discusses the waste of power in the four systems under the assumption that the same amount of copper is used; he gives equations for each case as also a set of curves showing the absolute and relative losses; the loss is greatest for the double loop, slightly less for the single loop, less still for the feeder system and considerably less for the direct system. The article is well worth the study of those interested, but care should be taken in applying the result. (The best practical rule for a large installation where the differences are appreciable, is to calculate the copper and other factors for each system, as their relative merits vary very greatly for different conditions.)

TELEGRAPHY AND TELEPHONY.

Belfast-Glasgow Telephone Line.—The Lond. "Elec. Rev." gives a short description of the line just completed between Belfast and Glasgow. The transmission is said to be exceedingly good, "three or four times as good" (according to what scale?), as the London-Paris lines. The distance is 150 miles (that of the London-Paris line is 303 miles); the cable portion is 23.5 nautical miles (in the latter it is 21); the cables on these two lines are practically identical; there are four conductors in the cable, each of the copper wires weighing 160 pounds to the mile and having a resistance at 75 degrees F. of 7.5 ohms per nautical mile; the gutta percha dielectric weighs 300 pounds to the mile and the capacity is 0.3 microfarad per mile; the difference between this and the London-Paris cable is that the former contains a sheathing of brass tape intended to protect the conductors from a certain species of teredo; the land lines are of copper 800 pounds and 1.12 ohms to the mile; there is one piece of underground line of about a mile in length in Glasgow, the copper being 150 pounds to the mile. The aim has been to make the copper wires as large as possible, and to use the least possible length of covered wire; the circuit is completely metallic; the two wires are made to exchange their positions by revolving or twisting each around the other, along the whole distance, like the strands of a rope, there being about 7 twists per mile; the charge for a three minute conversation is 5 shillings (about $1.25); in the London-Paris line it is 8 shillings.

Time Telegraphy.—Mr. Sesemann, in the "Elek. Zeitschrift," April 14, describes and illustrates an apparatus, which has been in successful use for some years, intended

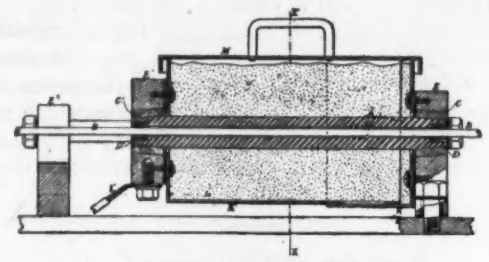


Fig. 1.—Rod and Rivet Heaters.

to connect branch circuits into a time circuit for automatic transmission of a daily time signal, and to supplant the repetition by hand which was formerly used.

ELECTRO-CHEMISTRY.

Chlorine and Caustic Soda.—Mr. Roux, in "L'Ind. Elec.," describes the Le Sueur process as follows: The vessels are of iron and are placed on an inclined table; the cathode is made of a ring of iron to which is attached iron wirecloth; the upper part of the ring is perforated to permit the escape of the hydrogen gas; a diaphragm is fastened to the cathode consisting of a sheet of parchment paper covered on both sides by a sheet of asbestos cardboard cemented to it with blood albumen; the anode is of retort carbon enclosed in a lead frame; in the exterior and interior receptacles is placed a solution of chloride of sodium the level of which in the former being slightly higher in order to prevent the passage of the soda into the interior cell. The diaphragms are changed every 24 hours and the anodes every 5 or 6 weeks; the electromotive force required is 4.5 volts. With 2,000 h. p. one obtains per 24 hours 8,426 kilograms of chlorine or 22.5 tons of chloride of calcium of 37 per

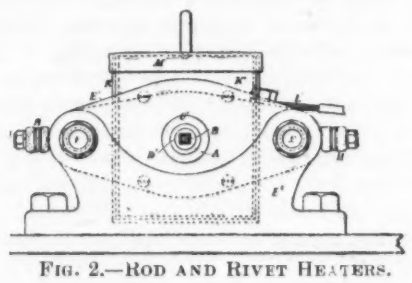
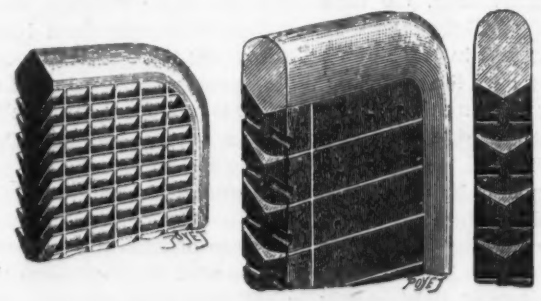


Fig. 2.—Rod and Rivet Heaters.

cent.; at the same time there will be produced 9.4 tons of caustic soda or 12.4 tons of bicarbonate of soda; the value of the products per 24 hours is given as $1,400 and the expenses as $600; the details of this estimate are given. The description of the apparatus is somewhat meagre. Regarding the process of Richardson and Holland, which is at present being used on a large scale, he says that with a current of 500 amperes and 80 volts the value of the products per 24 hours will be about $240, the profits on which will be about $75. The cost of producing 180 tons per week, that is, 52 tons of caustic soda of 76 per cent. and 128 tons of chloride of calcium of 35 to 37 per cent., would yield a profit of $75 per ton.

Aluminium.—In a serial in "L'Electricien," beginning with March 25, Mr. Haubtmann gives a general review and a short description of the various methods of producing the metal.

Accumulators.—The latest form of the accumulators



Figs. 1 and 2.—Accumulators.

as made by Philippart (the owners of the Faure patent in France) is shown in the accompanying cuts. Fig. 1 is the positive electrode of accumulators intended for central stations where the weight is of less consequence. Fig. 2 shows the positive plate of those in which weight is an object; the negative plate in the latter is precisely similar, but lighter. The capacities of the two types are 3.5 and 7.0 ampere hours per kilogram (total) for the smaller sizes and 5.5 and 10.7 for the larger sizes; the rate of discharge is .56 and .50 ampere per kilogram (total) in the smaller and .80 and .7 in the larger. The density of the solution must not be greater than 1.2 at charge; the charge is stopped at 2.25 and the discharge at 1.78 volts. The illustrations are taken from "L'Ind. Elec.," which contains also a more complete table of the data.

MISCELLANEOUS.

Rod and Rivet Heaters.—The issue of March 11 contained a reference to a new electric furnace of Mr. Siemens; this furnace has subsequently been described and illustrated in the Lond. "Elec. Eng.," April 7, from which the accompanying cuts were taken. Fig. 1 shows a section, and Fig. 2 an end view. A is the carbon cylinder, which is heated by the current; E E′ are the two contact terminals, the contact surface being conical; D D′ are pieces of refractory material acting as guides to prevent the iron rod from injuring the carbon; B is the iron rod to be heated, which is passed continuously through the furnace; the contact plates E E′ are held together by springs not shown, so as to take up the expansion and keep the contact perfect; the box K′ is filled with sand, mineral wool or other non-conducting material to prevent radiation. One of the great advantages of this heater is that it can be taken to the work itself, instead of having to take the work to it. If necessary, the tube may be supplied with a continuous flow of hydrocarbon vapor, nitrogen or other neutral gas in order to avoid oxidation of the metal rod. Another interesting modification shown is one for heating rivets; the carbon tube is in that case short, and enables a rivet to be inserted in each end with the head projecting; there are two tubes in series, enabling four rivets to be heated at a time.

Lightning Rods.—The Lond. "Elec. Rev.," April 14, abstracts an article by Major Pescetto, of the Italian Royal Engineers. The two fundamental principles are, first, the preventive; that is, the maintaining of an electric equilibrium between the clouds and the earth, so as to prevent the action of lightning; and, second, the preservative; that is, to supply a path for the discharge. It has often happened, however, that the best lightning rods have not protected the building; the fault has often been attributed to the earth connection. He formulates new rules which increase the probability of effective protection (these rules, however, are not given in the abstract). The duration of a flash of lightning does not exceed .00001 second; the discharge is almost certainly oscillatory, the frequency being above one million; he prefers iron to copper. In summarizing the points in controversy, he states that lightning rods, as now constructed, are frequently effectual, but sometimes fail even with the best earth, and may produce lateral discharges and promote discharges by induction; the conductivity is of much less importance than was formerly supposed, the self-induction being more important; the discharging action of needle points is insignificant, as hundreds of them do not suffice to discharge the electricity from a small induction machine; the zone of protection does not exist since lateral discharges may occur from the rod itself; a complete security would be presented by a metallic cage.

Coating of Cylinder Walls of Steam Engines.—In steam engines it would be very desirable to have the inside instead of the outside of the cylinder coated with a heat insulating substance; this Prof. Thurston has stated to be "the final and last improvement" of the steam engine. Mr. Bandsept, in an article from the French, translated in the Lond. "Electrician," proposes to do this by incorporating with the metallic surfaces previously expanded by heat, refractory non-conducting substances, finely divided and projected against them by means of a sort of sand blast. The surfaces are heated by placing the cylinder in an electrolytic bath and passing a current through the bath, the cylinder being one of the electrodes; when the current passes, the surface of the metal becomes red hot (presumably as explained in the first paragraph, page 320, of last week's issue). When it emerges from the bath, while thus heated, it is subjected to the action of the sand blast; in order not to require too much current the surfaces are treated in sections; thus heated the heat does not penetrate far into the metal; the surfaces merely need polishing after this treatment.

Electric Furnace.—In a later form of the Moissan electric furnace, as made by a firm in France, and illustrated in a number of the foriegn journals, a large U-shaped compound permanent magnet is placed outside the furnace so as to act on the arc, giving it a fixed location; this is said to produce an action more like the flame of a blow pipe. The best form of screen to protect the operator is found to be one made of gelatinous bromide of silver, as used in photography, and which can be made as opaque or transparent as desired; it does not get as hot as others.

Electric Furnace.—"L'Electricien," April 8, contains a descriptive article illustrating six forms of electric furnaces of the Moissan type. The most important of these have already been illustrated or described in these columns.

Training of Electrical Engineers.—The Lond. "Elec. Eng.," April 14, contains a second paper on this subject, as also two letters in their correspondence columns.

Some Large Water Power Stations.

The use of water power for the operation of electric light and power stations is becoming more and more general, and an installation of this character is always of interest. It is to the West, perhaps, that we look for the greatest development in this line, on account of the many natural advantages of that section of the country.

The Black Eagle Falls, Great Falls, Mont., furnish an admirable location for a water power plant. A dam 15 feet in height and 1,100 feet long, has been built across the river, which gives a total fall of 40 feet, and an estimated horse power at the northern end of 20,915, and at the south end 11,952. The dam has been constructed by the Great Falls Water Power and Town Site Company at a cost of $275,000. An electric power station has been constructed on the south bank of the river below the falls. The power house is a brick structure 40 by 165 feet, two stories in height. A centre tower is provided, from which the feed wires lead over supporting posts to the top of the neighboring block.

The power equipment consists of three twin horizontal

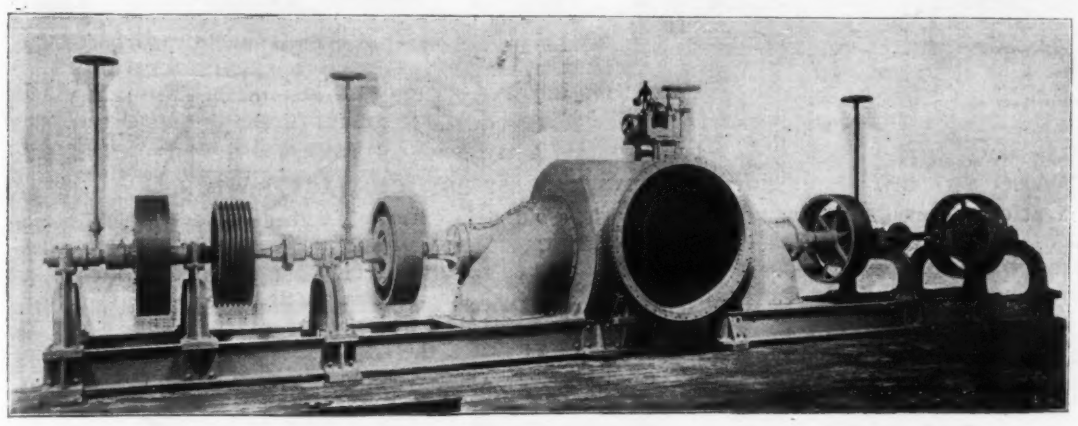


FIG. 1.—VICTOR TWIN TURBINE AT GREAT FALLS, MONT.

Victor turbine wheels, manufactured by the Stilwell & Bierce Manufacturing Company, Dayton, O. The wheel for the railway plant is shown in Fig. 1 and consists of a twin turbine, two shafts of which may be coupled together within a case. The shaft is 5 inches in diameter and 46 feet long. The twin wheels are 22½ inches in diameter and have a capacity of 400 h. p. The shaft at one end is equipped with 54-inch pulleys, from which the railway generators are driven, and the opposite end with three pinion pulleys, one of which drives a generator, the second the winding machinery for the inclined railway, while by the groove pinion the shaft is coupled to a 12-foot balance wheel by means of rope belts.

The case of the turbine is 7 feet long and 7 feet in diameter, the discharge pipes being each 3½ feet in diameter. The total fall of water is about 40 feet, and the turbines are placed 28 feet below the head, which gives, on account of the vacuum produced by the remaining fall, the same efficiency as if the wheel were located at the lowest point.

Two other wheels are employed, for lighting purposes, one of 400 h. p., which drives the arc light generator, and one of 300 h. p. coupled to the incandescent lighting dynamo. The present capacity of the plant is 1,100 h. p., and a fourth wheel of 600 h. p. is soon to be added. Some difficulty has been experienced in properly governing the wheels. A Snow governor is being employed, and experiments have also been made with the electric governor of the Holtzer-Cabot Electric Company. The generators of both the railway and lighting plant are located on the second floor and are driven by belts direct from the turbine shaft, which for the railway plant make 350 revolutions a minute. The power for the operation of the railway is furnished by two Thomson-Houston generators, and the current for the incandescent circuit is supplied from three A-70 Thomson-Houston alternating generators, with a capacity of 1,300 lights each. The arc circuit is fed by four Thomson-Houston M. P. 2,000-c. p. machines.

Another interesting water power station is that of the Washington Water Power Company, at Spokane, Wash., whose station is located on the right bank of the Spokane River, below the falls. The water is taken from the dam at the second falls and is conveyed in a pair of 7-foot steel penstocks a distance of 500 feet. The power station is a brick building 60 × 120 feet and two stories in height. The penstocks are led along the first floor side by side, and the Victor horizontal turbines, one of which is shown in Fig. 2, manufactured by the Stillwell & Bierce Manufacturing Company, Dayton, O., are connected by branches to the right and left. The shafts of the wheels are 20 feet above the tail race, to which the turbine is connected by draft tubes. The generators for street railway work are driven by twin wheels 17½ inches in diameter, of 400 h. p. The outer shell is about six feet in diameter and the discharge pipes three feet. A Snow governor is employed on the wheels to drive the electric light generator, but this is not found sensitive enough to regulate the power wheels, on which is used a governor manufactured by A. W. Woodward, of Rockford, Ill. The driving pulleys on some of the smaller wheels are smaller than the armature pulleys to which they are connected, as the wheel shaft makes 1,000 revolutions and the armature only 700. The generators are located on the second floor, and for the power plant consist of five Thomson-Houston generators of 80 h. p. each, two Edison generators of the same power and five pairs of 60 kw. each, and one pair of No. 16 Edison machines. The lighting plant consists of 12 Thomson-Houston M. P. dynamos, one American 50-light machine for the arc circuit, 1 A-50 Thomson-Houston alternator with exciter, and one Brush machine of 1,200 c. p.

The company supplies power for a large number of stationary motors about the city, including a 175-h. p. motor which operates the machinery of a neighboring brewery. The charge for motor power is from $3 to $5 per h. p. per month, and a charge per day of $2 per car is made where current is supplied to other companies.

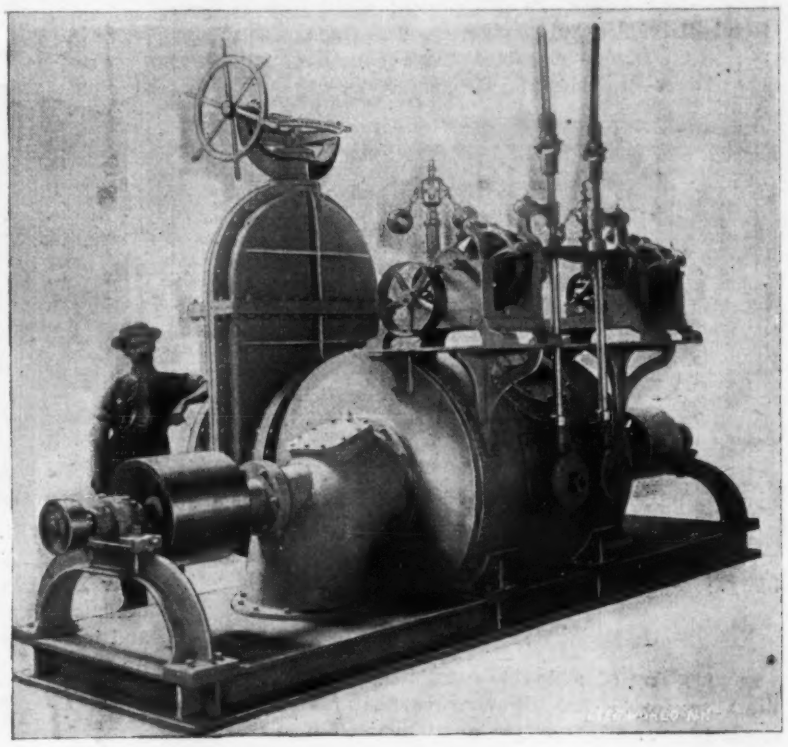
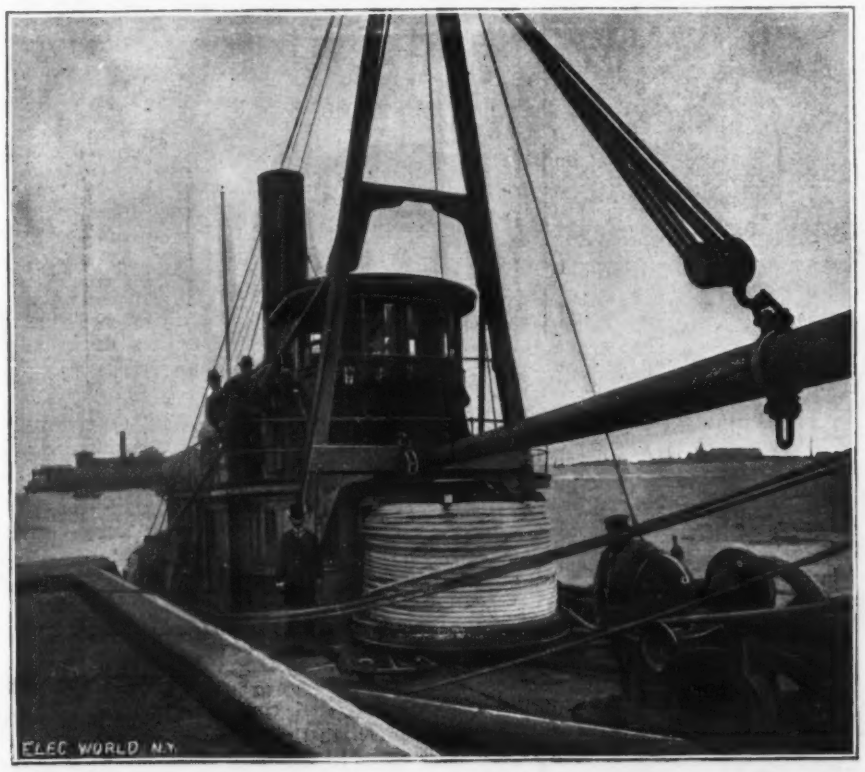


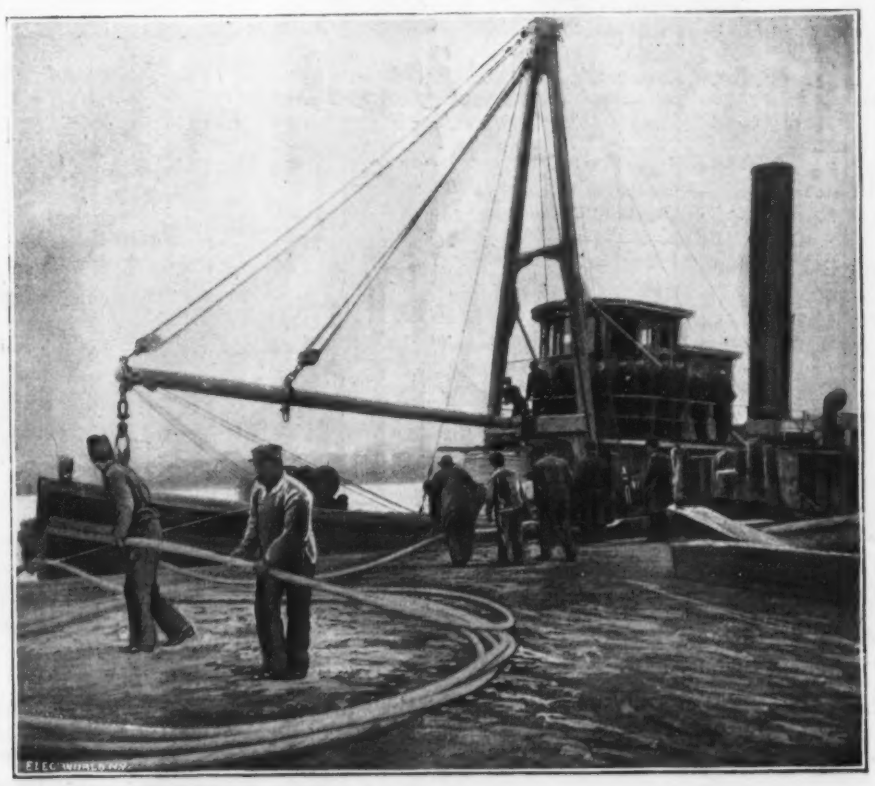
FIG. 2.—VICTOR HORIZONTAL TURBINE AT SPOKANE, WASH.

A Chapter in Submarine Telephony.

When, a few weeks since, in the presence of many of those prominently interested in this line of work, the submarine cable was laid from the foot of Vesey street, New York City, to the foot of Morgan street, Jersey City, another interesting step in the progress of submarine telephony was taken. The laying of this cable was skillfully planned and executed, and attended by the success which has followed the previous efforts in this direction. The accompanying illustrations are reproductions of photographs taken during the actual process of laying the cable. This is the ninth special 18-conductor submarine cable built for the Metropolitan Telephone and Telegraph Company, by W. R. Brixey, the well known manufacturer of Day's Kerite cables, under specifications drawn up by telephone experts for use in connection with long distance telephone service. The submarine cable has come to play an important part both in long distance telephony and telegraphy, and its manufacture and maintenance are attended by greater difficulties than the public is generally aware.

It forms the connecting link which renders communication possible between a city surrounded by water as New York is and the rest of the world. It should not be thought, however, that the work is finished when the



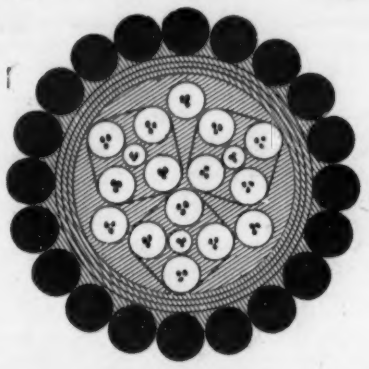


LAYING A KERITE CABLE ACROSS THE NORTH RIVER.

cable is laid, for the maintenance of it is a matter of no small account. It is likely to be damaged after being submerged by the fouling of anchors of vessels, or by the action of a strong tide forcing submerged matter against it. The utmost vigilance is required to see that no breaks or serious injuries to the insulation occur.

The length of this cable is 5,300 feet, somewhat more than a mile, and its weight 27,600 pounds to the mile. It consists of 18 strands or small conductors, being made up, as shown in the accompanying illustration, in reality of three cables, each part consisting of four conductors with a return wire for a complete metallic circuit and two extra or spare conductors. The process of manufacturing these cables is accompanied with great responsi-

bility and it will be seen that on account of their great weight and size the utmost care must be used in handling them after they have been completed at the factory. Perhaps no company in this country has had such wide experience or universal success in the manufacture and laying of submarine cables as has the Kerite company. As an evidence of the amount of submarine work turned out by this company it is only necessary to note the cables laid by it in this vicinity during the past 14 years, which include the following: Telephone cables under North River—29 cables, 236 conductors; under East River—four cables, 29 conductors; under the Harlem River—18 cables, 301 conductors. Telegraph cables under the North River—53 cables, 389 conductors; under the East River—9 cables and 63 conductors.



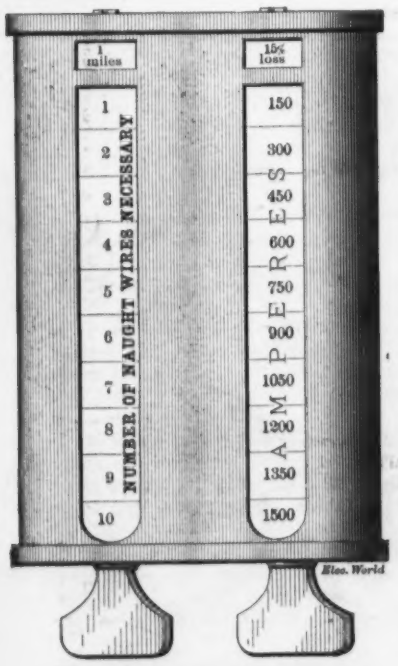
SECTION OF KERITE CABLE.

These cables have been from one to 14 years in active service, which is a sufficient testimonial of their durability.

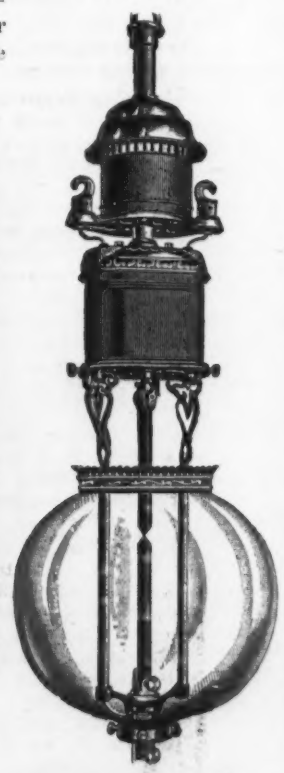
A Mechanical Wire Computer.

In this day of slide-rule calculators it is but natural that the simple case of wire calculations should be similarly provided for. The instrument we illustrate has been devised by Morton Carlisle, Carlisle Building, Cincinnati, Ohio, and consists simply of a case containing two cylinders on which are respectively columns of amperes and sizes of wires. By turning one cylinder until the given percentage of loss appears at the upper opening and then the other cylinder until the distance to which the current is to be carried similarly appears at the other corresponding opening, the gauge of wire or number of wires of a definite gauge required is that opposite the given amperes.

As will be readily seen this instrument is a substitute for the ordinary wiring table, but its greater convenience will no doubt be appreciated by wiremen. The instrument is made for the various voltages used and may be had either nickel-plated with paper scales on the cylinders, or with both case and cylinders of aluminium with the numbers on the latter stamped into the metal.



WIRE COMPUTER.



KESTER ARC LAMP.

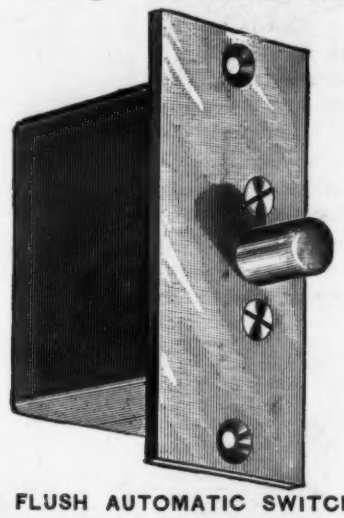
C-S Flush Automatic Switch.

It is probable that in no other industry of the country has there been such general stimulation to invention as in the field of incandescent electric lighting apparatus, and among those best known in this connection is the Cutter Electrical and Manufacturing Company, of Philadelphia, which has recently added to its well known line of "C-S Specialties" a "Flush Automatic Switch," shown in the accompanying illustration, for use in bath rooms, dark closets, etc., etc.

The switch is set flush in the rabbet of a door jamb in a manner similar to the familiar burglar alarm spring, and its action is strictly automatic in all that the term implies. Every time the door is opened the light is turned on, and every time the door is closed it is turned off. Nothing can be disarrranged by the accidental opening or closing of the door at the wrong time, consequently it requires no attention or adjustment whatever after it is once set up.

This switch may also serve as an efficient burglar alarm, as an intruder is at once confronted by a bright light upon opening a door. Another convenient application is to attach it to the front door, so that an occupant of a house, upon entering, finds a hall light to welcome him.

Although this device has been but a short time upon the market its great convenience has been readily appreciated. The newly erected New Netherlands Hotel in New York has already been equipped with several hundred, and we are informed that other prominent hotels and institutions in the country are similarly being fitted up with it.



C-S FLUSH AUTOMATIC SWITCH.

The Kester Improved Arc Lamp.

The F. P. Little Electrical and Construction Company, of Buffalo, N. Y., has recently acquired the patents and selling rights of manufacture of the Kester improved arc lamp, the invention of J. F. Kester, and until lately manufactured by the A. H. Atwood Manufacturing Company, of Chicago. This lamp has many features which place it in the front rank for an arc lamp to be used on incandescent circuits. The excellent feeding mechanism of its novel differential feed action causes the lamp to produce a clear steady light. Its parts are fewer by half, it is claimed, than those of any other lamp made, there being less than one dozen machine screws in the lamp, no solder or rivets, and only one spring. On account of the feeding mechanism, the consumption of current is claimed to be remarkably small.

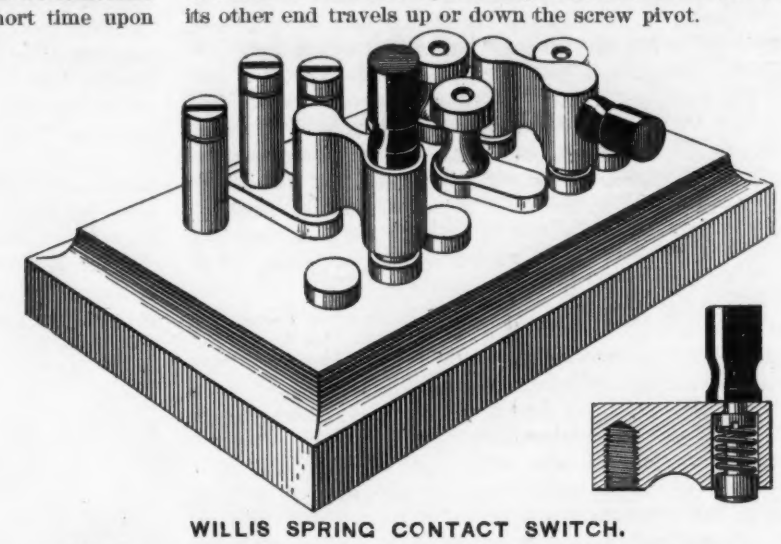
Every part is made interchangeable and can readily be replaced, and as a proof of the accuracy of the manufacture of the various parts it is claimed that not one in ten requires readjustment after leaving the assembler's hands. The lamp is constructed under the personal supervision of Mr. Kester, its inventor.

The Willis Spring Contact Switch.

Whoever has had experience with small switches will appreciate the advantages of one in which the contact is always constant and the pivot of the swinging arm has never to be adjusted. We illustrate a switch, designed and manufactured by Mr. D. J. Willis, 195 Broadway, New York, in which these points have been realized and several other improvements introduced.

The pivot of the lever is a screw secured to the base by a nut below and a brass plate above, so that it is firmly attached. The lever in swinging advances up or down slightly on the thread of this screw, and thus the motion is always free, with no possibility of binding or the reverse.

The contact is secured by a plug in a recess in the other end of the lever, a spring behind keeping the contact constant and at the same time permitting the plug to advance or recede by the slight amount the lever at its other end travels up or down the screw pivot.



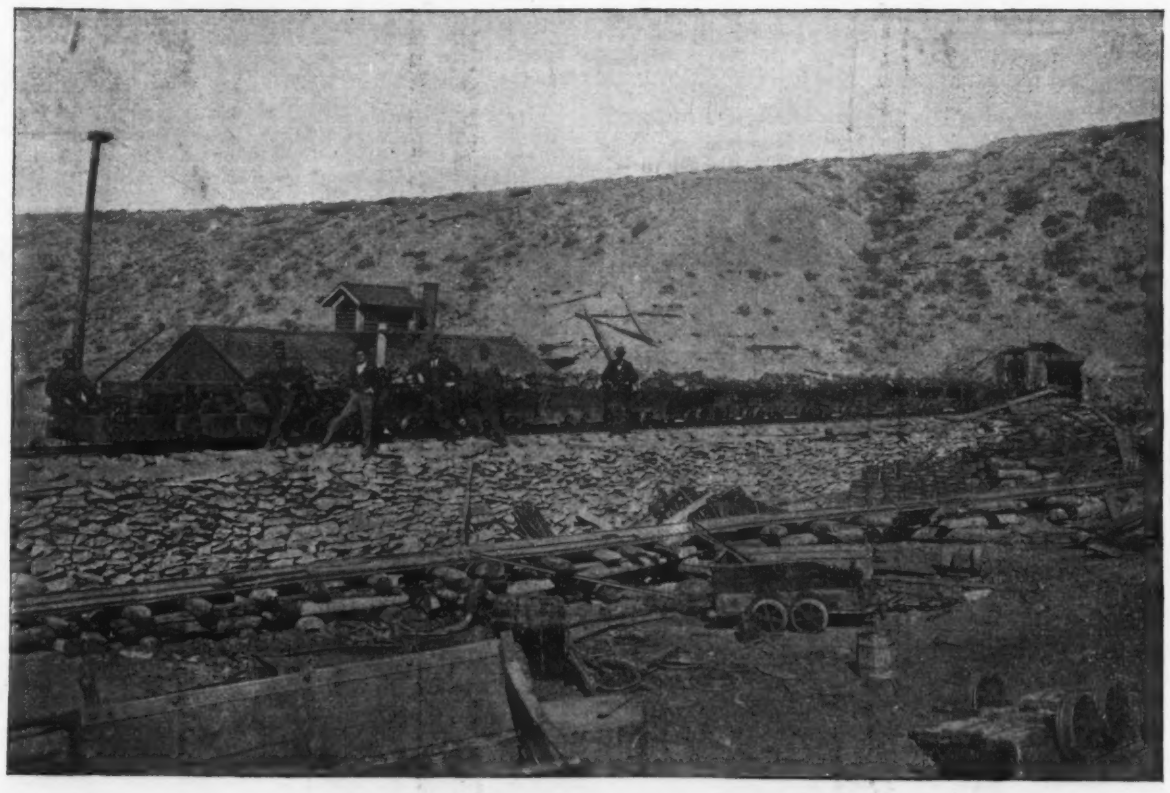
WILLIS SPRING CONTACT SWITCH.

The old style of switch with a contact generally too tight or too loose and with an occasional loose pivot wire has caused no little trouble, sometimes throwing out a wire through the impression that the defect was elsewhere, perhaps on the line.

In this switch the free motion of the lever, the constant spring contact and impossibility of the wire connection on the lever pivot working loose are advantages that make this switch a notable improvement. The cut shows two forms of the switch and the swinging arm in section.

Electric Haulage in Coal Mines.

The problem of economic haulage in mines has lately received considerable attention from mine owners, who have found the expense involved in haulage alone much greater than in their opinion it should be. The mule has had his day as the principal factor in the haulage question, and the cable is under test, with results more or less satisfactory. The electric locomotive for mine work is comparatively a new comer in the haulage field, but it has already acquired considerable prestige and bids fair to supersede both the mule and rope haulage.



ELECTRICAL HAULAGE IN COAL MINES.

An excellent example of the work done by the electric locomotive in coal mining is shown at the Rock Springs Coal Mine, at Rock Springs, Wyo. This plant was installed by the Mining Department of the Northwest General Electric Company.

About a mile from the mouth of the mine the power station, containing a dynamo of 80 h. p. driven by a steam engine, is located. Current from this is delivered at a pressure of 550 volts, which allows of a drop of about 10 per cent. between the power house and the mine.

The feed or supply wire is No. 000 hard drawn bare copper, making a complete metallic circuit. The trolley line is furnished with a circuit breaker about 30 feet from the mine mouth, so that the current may be cut off from the mine when the locomotive is employed for switching purposes outside.

The locomotive used is of the G. L. M. General Electric Company type, of 30-inch gauge, 60 h. p., recently described in our columns. Its usual speed in this instance is about eight miles an hour. The cars used are of the ordinary coal mine type, weighing each, when filled, about 3,000 pounds, when empty about 1,000 pounds.

The economy attained by the use of this locomotive is strikingly illustrated by the fact that by its aid 30 cars were run from the loading point to the end of the track, a distance of about 6,000 feet, there dumped and returned to the mine in 20 minutes. On another occasion the locomotive drew after it 30 loaded cars, and pushed ahead 16 others from end to end of the road without difficulty. The track is built of 35-pound T rail and has several switches and spurs necessary to the rapid handling of the cars.

It is not inapropos here to quote from a letter from the expert, giving an account of contact with the bare wire and the results thereof:

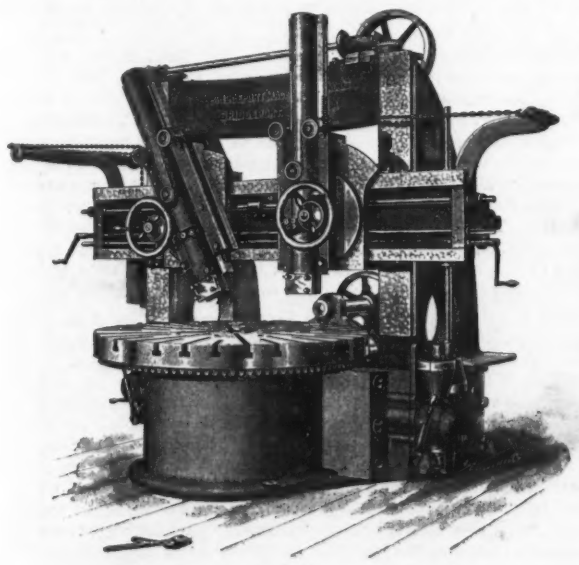
"Several men have been shocked since our plant began operating, but the effect is only momentary and they only laugh at it. The result has simply been to remove all fear they had of it. As I stated in my letter, this is a very dry mine and so the only way one can get shocked is to stand on a rail and touch the wire. I have been shocked several times myself while handling the locomotive, through thoughtlessness. The other day a balky mule ran right into the wire with his head. He was knocked down. He got up and ran into it again three times and was dropped in every instance. After that he simply turned around and walked off to his work. I ought to remark that the shock does not knock a man down or burn him. The only description I can give of its effect from personal experience is a tingling sensation, lasting, in the heaviest shock I received, not more than one or two minutes afterward in the hand that made contact."

New 62-Inch Boring and Turning Mill.

The machine illustrated is manufactured by the Bridgeport Machine Tool Works, E. P. Bullard, proprietor, Bridgeport, Conn., and is the result of eight years' experience in the manufacture of tools of this class. It embodies all the essential features of their smaller mills, and contains many new ideas, which have been suggested by past experience. This company has recently enlarged its works, and added many special tools and fixtures for making and handling machines of this character.

The capacity of the mill is 62 inches in diameter and 42 inches in height. The table is 58 inches in diameter and is powerfully geared, and has 16 changes of speed. The teeth on table, as well as on pinion, are accurately planed. The heads are constructed so that either one may be brought to the centre, and can be set at any angle; they carry the tool bars, which have a movement of 30 inches. Each head has an entirely independent feed in any direction.

The feeds are all positive, and range from 3-64 to ¾

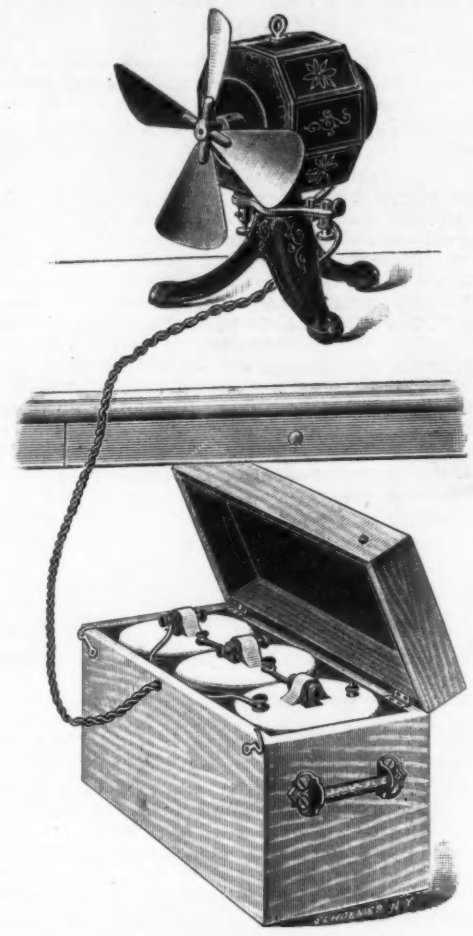


BORING AND TURNING MILL.

of an inch horizontally, and from 1-64 to ⅜ of an inch in angular and vertical directions. The cross rail is raised and lowered by power. The machine is self-contained, thus avoiding the necessity for building an expensive foundation, and weighs 20,500 pounds.

The Edison Manufacturing Company's New Ironclad Battery Fan Motor.

This fan motor has been designed by the Edison Manufacturing Company, of 110 East Twenty-third Street, New York, with especial reference to primary battery operation. The friction of its armature bearings and brushes has been reduced as far as practicable, and it runs a 7-inch four-bladed fan at 1,000 revolutions per minute, with 2.0 amperes and 1.5 volts at terminals. It gives an almost noiseless delivery of steady breeze for table or desk use, and its presence will be very welcome during the approaching warm weather. The battery consists of three Edison-Lalande Q cells in an oaken box. The capacity of one charge in this battery is 150 ampere hours, with practically no loss from local action when the motor is out of use. By this means the battery will last ten weeks without renewal at one hour's work daily, or ten days at a steady operation of 7½ hours per diem. For



IRONCLAD BATTERY FAN MOTOR.

the parlor or dining table the fan is an attractive ornament, while at the bedside, either on a table or suspended from the wall, it is a most agreeable companion, being so nearly silent. Its bearings are self-oiling, carrying on their own lubrication without loss or rejection of the lubricant, and the oil in the wells need only to be changed whenever the battery is recharged.

The armature, as the motor's name suggests, is entirely inclosed in an iron box or ornamental field frame, with a glass window at one end through which the brushes and commutator can be inspected. This arrangement combines all the advantages of an ironclad motor as to compactness, safety, noiselessness, cleanliness, efficiency, etc., with the particular and novel feature of leaving the brushes always open to examination. To remove the glass window and readjust or replace a brush after months of wear is only the work of a few moments, and the plan adds greatly to the convenience, simplicity and finish of the machine.

The battery box occupies a space of 18¾ inches × 7 inches × 9¾ inches, and can therefore be always accommodated without inconvenience.

NEW BOOKS.

VADE MECUM. A Work of Reference. Compiled and arranged by D. B. Dixon; with a Comprehensive Treatise on Electricity, by Thomas G. Grier. Chicago: Laird & Lee. 1893. 480 pages, illustrated. Price $2.50.

As a work of reference for architects, contractors, engineers, mechanics, etc., this book will be found useful, being based apparently on the well known Haswell's Manual. It contains 498 tables appertaining to metals, wood, stone, etc., with rules illustrated by problems which apply to mechanical engineering and its allied arts and sciences. All rules are based on common arithematic, algebra and the higher mathematics being avoided.

The "Comprehensive Treatise on Electricity" consists of 64 pages devoted to definitions of the units, wiring and copper tables, some wiring diagrams, some remarks on dynamos, motors and related matters, and insurance rules. This section would lose little in value if all except the tables and insurance rules were omitted.

The book is well printed with clear type on good paper, and very substantially bound, and can be recommended as a useful mechanical and electrical work of reference for the office desk and library.

FIFTY YEARS HENCE, OR WHAT MAY BE IN 1943: A PROPHECY SUPPOSED TO BE BASED ON SCIENTIFIC DEDUCTIONS BY AN IMPROVED GRAPHICAL METHOD. By Robert Grimshaw. New York: Practical Publishing Company. 1892. 89 pages. Price $1.00.

This clever little book, of the Battle of Dorking order, has a somewhat greater merit than such works usually possess from the author's technical knowledge of real tendencies. Electricity naturally occupies a prominent part in the book, which is agreeably written, and will furnish a half hour's interesting reading.

NEW INCORPORATIONS.

The Berlin Building Company, Tacoma, Wash., capital stock $115,000, has been formed to build electric light plants, &c. C. Muelenbruch and H. Mahncke are the interested parties.

The Canton-Salem Electric Company, Canton, O., capital stock $30,000, has been organized to supply electricity. J. B. K. Turner, J. Hadley, T. Cooper, R. A. Carran and A. A. Thayer are the incorporators.

The Consolidated Electric Company, Chicago, Ill., capital stock $50,000, has been formed to manufacture and deal in electrical appliances, etc. L. B. Scott, C. P. Emmons and C. Oskamp are the promoters.

The Mount Vernon Electric Street Railway Company, Winton, Pa., capital stock $24,000, has been formed to construct and operate an electric railway. T. Reddington, J. Ward and P. C. Walsh are the promoters.

The South Milwaukee Light and Power Company, Milwaukee, Wis., capital stock $15,000, has been formed to establish a light and power plant. F. H. Brice, W. W. Williams and C. W. Bee are the interested parties.

The Dalles Electric Light, Telephone and Power Company, The Dalles, Ore., capital stock $50,000, has been formed to deal in electricity producing apparatus. G. V. Bolton, G. Bush and H. C. Neilson are the promoters.

The Montana Electric Company, Butte, Mont., capital stock $50,000, has been formed to do a general electrical business. J. O'Rourke, G. T. Schmelzel, S. B. Smith, W. T. Jackson, V. E. Poissant and C. L. Smith are the organizers.

The Atwater General Electric Company, Cleveland, O. capital stock $14,000, has been formed to manufacture electrical apparatus. F. B. Many, A. S. Atwater, L. Case, G. M. Schambs and W. A. Merrill are the interested parties.

The Hewett Voltaic Electric Company, Jersey City, N. J., capital stock $150,000, has been formed to manufacture and buy electric batteries, etc. J. J. Toffey, J. H. Potts, Jersey City, and C. T. Griffiths, New York, are the incorporators.

The Madison Electric Light and Power Company, London, O., capital stock $10,000, has been formed to produce electricity for light and power. D. C. Badger, J. F. Locke, H. H. Prettyman, M. S. Murray and John Riley are the promoters.

The Millbury, Sutton & Douglas Electric Railroad Company, Millbury, Mass., capital stock $200,000, has been formed for the purpose indicated by its name. T. N. Babson, F. A. Harrington and J. W. Stockwell are the incorporators.

The Marion City Railway Company, Marion, Ind., capital stock $500,000, has been formed to build and operate a street railway, light, heat and power company in that town, etc. G. G. Wharton, P. Matter and J. V. Sweetser, all of Marion, are the promoters.

The Milwaukee & Waukesha Railroad Company, Milwaukee, Wis., capital stock $25,000, has been incorporated to build a railway and to operate an electric plant. A. F. Tanner, J. Beeb, S. I. Henderson, F. G. Conrad and F. W. Henderson are the promoters.

The American Engine Company, New Bound Brook, N. J., capital stock $200,000, has been formed to manufacture electrical machines, etc. R.V. Pierce, E. J. Brandt, New Bound Brook; E. E Spaulding and B. T. Bedortha, Bound Brook, N. J., are the promoters.

The Allegheny Improvement Company, East St. Louis Ill., capital stock $500,000, has been formed to erect and operate telephone, telegraph and electric light plants, etc., etc. R. C. Kerens, G. B. Leighton, C. H. Smith, F. W. Schaurte and P. M. Hoefle are the promoters.

The Western Light and Power Company, San Francisco, Cal., capital stock $500,000, has been formed to carry on the electrical business in all its branches. M. Krueger, C. Shelley A. Bouvier, F. Daniels and H. Greenberg, San Francisco, Cal., are interested.

The Union Multiplex Telegraph, New York City and Helena, Mont., capital stock $20,000,000, has been formed to construct telegraph lines and to manufacture the necessary apparatus, etc. G. P. Schokley, E. H. Galing and Wm. Essen, New York City, are the incorporators.

The Beecher Single Rail Railway Company, of Buffalo, N. Y., capital stock $400,000, has been formed to manufacture and sell all kinds of electric motive power, locomotives, etc. C. A. Seaver, Lina Beecher and G. C. Hardesty, all of Batavia, N. Y., are the promoters.

The Essex-Hudson Light and Heat Company, Newark, N. J., capital stock $2,000,000, has been formed to manufacture machinery, etc., for producing electricity, etc. G. R. Gray, Newark, N. J.; E. McMillin, Columbus, O., and H. B. Wilson, New York City, are the organizers.

The Put-in Bay & Southwestern Electric Railroad Company, Tiffin, O., capital stock $3,000,000, has been formed to construct and maintain a railroad between Ottawa and Findlay. G. B. Kerner, J. K. Tillotson, A. Tablem, C. A. Gordon and J. B. Foraker are the organizers.

The Clark Automatic Telephone and Equipment Company, Sioux City, Ia., capital stock $190,000, has been formed to manufacture and sell electrical supplies. E. W. Rice, N. Desparois, J. C. Lawler, H. S. Baker, W. C. Lyon, E. A. Clark and J. H. Quick, Sioux City, are the promoters.

The Cleveland Electric Railway Company, Cleveland, O., capital stock $6,500,000, has been formed by a consolidation of the East Cleveland Railroad Company and the Broadway & Newburgh Street Railroad Company. H. A. Everett, H. E. Andrews and R. A. Harman are the interested parties.

The Electric Transit Company, Camden, N. J., capital stock $100,000, has been formed to operate or deal in electric and other appliances. J. W. Haynes, New Brunswick, N. J.; J. A. Wright, T. P. Vaille, Philadelphia, Pa.; J. S. Thayer, Hammonton, and G. S. King, Camden, N. J., are the promoters.

The United States District Messenger Call Company, Jersey City, N. J., has been formed to purchase and sell patents for messenger calls and other electrical appliances. H. S. Clark, Warren; J. H. Loomis, Chicopee, Mass.; E. Insley, Nanuet, N. Y., and R. Davis, Jersey City, N. J., are the organizers.

The Passaic, Bloomfield, Montclair and Caldwell Electric Railway Company, Passaic, N. J., capital stock $200,000, has been formed to construct and operate a street railway. E. N. Frisbie, G. B. Waterhouse, M. E. Worthen, J. Kennell, Passaic, and J. F. Lowe, Jersey City, N. J., are the promotors.

The Citizens' Telephone Company of Quincy, Quincy, Ill., capital stock $100,000, has been formed to construct and operate a telephone exchange, and also to manufacture electrical goods. C. H. Castle, G. J. Cottrell, W. R. Lockwood, J. L. Martin, J. R. Smith, W. S. Warofield and George Wells are the promoters.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-176 TIMES BUILDING, NEW YORK, May 1, 1893.

The Hall Signal Company on and after May 1 will have its general offices at 80 Broadway, Union Trust Building, New York City.

The Conover Manufacturing Company, manufacturers of the Conover condensers, have moved from 95 Liberty street to 39 and 41 Cortlandt street.

The Wheeler Condenser and Engineering Company has moved from 92-94 Liberty street to 39-41 Cortlandt street, where it occupies a large suite of offices.

Mr. Charles R. Truex, late of the firm of Truex & Vail, and formerly special agent for the American Bell Telephone Company, is now connected with the Long Distance Telephone Company as special agent.

A Trip to the Moon at the Carnegie Music Hall has proved to be a great attraction. The opportunity for the introduction of electrical effects has been taken advantage of by the managers in every way, and the result has been a most attractive and interesting display.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 91, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Mass., April 29, 1893.

The Milton Light and Power Company, of Milton, Mass., is contemplating an extension to its lines this spring.

The contract for lighting the Bristol Mills at New Bedford Mass., has been awarded to the Mather Electric Company, of Boston.

The Coventry Electric Light Company, of Coventry, R. I., has been organized for the purpose of building and operating an electric light plant at that place.

The citizens of North Attleboro, Mass., will vote on a proposition to issue bonds to the amount of $50,000, for the purpose of establishing a municipal electric light plant.

At a recent town meeting at North Attleboro, Mass., it was voted to furnish the town with an electric light plant for street and commercial lighting. The price will not exceed $50,000.

Councilmen Baldwin, Allen and Bradford, of Cambridge, Mass., have been appointed a committee to investigate the subject of electric lighting, with the view to establish a municipal plant.

The Beverly & Danvers Street Railway Company (Mass.) has petitioned for permission to equip its road with the trolley system. If this is granted the Lynn & Beverly will probably acquire this road also.

The Trayne estate will shortly erect a large building in Providence, R. I. The structure will be wired for electric lighting. Edward F. Ely, 874 Broadway, New York, has been engaged to draw the plans.

The directors of the Lowell & Haverhill Company have purchased a large tract of land on Water street, Haverhill, from A. H. Adams, and propose to erect thereon an immense car shop, factory and repair shop.

Chas. C. Haight, 111 Broadway, New York City, is preparing plans for a dormitory at New Haven, Conn., for Yale University. The building will be wired for electric lighting and will cost when finished $500,000.

The Hamilton, Watertown and Guelph Railway Company, of Hamilton, Can., will begin work shortly on the construction of its proposed electric road between the points named. W. P. Howland, of Toronto, Can., is interested.

The congregation of St. John's Protestant Episcopal Church, of Newport, R. I., of which Rev. Dr. Buck is pastor, will have plans prepared for a new edifice to be erected at that place. The structure will cost about $100,000 and will be lighted throughout by electricity.

The Consolidated Electric Manufacturing Company, of Boston, Mass., at a recent meeting re-elected William Rotch president. Parker C. Chandler was chosen treasurer in place of Chas. C. Winter, retiring, and Chas. E. Bibber was re-elected general manager.

C. E. Woodruff & Co., successors to the Globe Supply Company, Chicago, have been appointed the Western representatives of the American Circular Loom Company, of Boston, Mass., well known manufacturers of canvas jacket cables, telephone and telegraph and electric light wires.

The Marlboro Street Electric Railway Company, of Marlboro, Mass., proposes to purchase land for a new car house and to buy new cars, also to petition the Board of Aldermen for leave to extend the road to the Southboro line. S. H. Howe and Thomas T. Robinson, of Boston, are directors.

The Massachusetts Chemical Company, Boston, Mass., reports that business with it has never been better. Mr. Harry Bishop, the Chicago representative, is daily sending in his orders, and the Boston office is doing all it can possibly handle. Insullac is appreciated by all who have used it.

The Electric Gas Lighting Company, Boston, Mass., is introducing its new line of burners. These embrace the following: "Boston Ratcher Burner No. 3," "Single Wire Triumph Automatic," "New By-Pass Ratcher Burner No. 3½," "Thumb-Cock Burner No. 13," "Regular Tilting Gas-Cock Burner No. 10," and "Standard Simple Hand Lighter No. 5."

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, April 29, 1893.

The Sperry Electric Railway Company will have its principal office hereafter at Mason and Belden streets, Cleveland, O.

The Phoenix Iron Works Company will have its Western office, of which Mr. D. W. Davis is manager, at 519 The Rookery, Chicago, after May 1.

Mr. William A. Rosenbaum, of New York, made us a pleasant call on his return east from Colorado, where he has been for the past ten days taking testimony in an interference case.

The Chicago Spectatorium is the new name given to the building erected on the World's Fair grounds, and which up to the present has been known as the Mackaye Spectatorium. This change was made at the request of Mr. Steele Mackaye, after whom the structure was first named, in recognition of the public spirit of Chicago.

Mr. William W. Nugent, 823 Insurance Building, corner La Salle and Adams streets, Chicago, Ill., has succeeded J. M. Hayes as manager of the C. & G. Cooper Company, Mt. Vernon, O., the well known manufacturers of Corliss engines. Mr. Nugent has had a wide experience as contracting and consulting engineer, and will, no doubt, meet with success in this line of work.

The Ansonia Electrical Company, formerly the Electrical Supply Company, of Chicago, Ill., has already commenced the shipment of the new Sunbeam incandescent lamp. This company also manufactures an excellent form of dry battery known as the Ajax, which has now been on the market for some four years. A colossal Ajax dry battery has been prepared for exhibition at the World's Fair, which, it is claimed, will give a current of seven ampères at six volts. Its dimensions are 30 inches high by 12 inches in diameter. It will be used on the temporary circuit by which the President will start the machinery of the great Exposition at the opening ceremonies.

Mr. L. H. Rogers has recently been appointed assistant general manager of the Brush Electric Company, Cleveland, O. Mr. Rogers some years since was connected with the Eastern offices of the Brush company, when they were managed by S. M. Hamill, the present general manager of the Brush company. Subsequently Mr. Rogers became connected with the General Electric company of Boston. He moves with his family from Boston to Cleveland, where he will reside. Mr. Rogers was for some years connected with the Electric Accumulator Company under the presidency of Theodore N. Vail. He has had a large experience in the electrical business, and will be a valuable officer for the Brush company. He is well known as the originator and owner of the Mount Washington search light which he placed on the summit of the mountain during the summer of 1892. He has recently been experimenting with this search light with a view of throwing intelligible words and characters long distances. He has succeeded in utilizing the clouds for a screen, and a company is now being formed.

OREGON CITY, Ore., April 24, 1893.

The Arnold Novelty Company, of Tacoma, Wash., has made arrangements with the Holtzer-Cabot Company, of Boston, to manufacture the Arnold Electric Flexible Bracket in future.

The Oregon City "Enterprise" has just had a 10-h. p Edison motor installed in its press rooms, which will be operated from the Portland General Electric Company's new power circuits.

The Portland General Electric Company has just installed in its Oregon City station two Victor horizontal turbine water wheels, one of 750 h. p. and the other of 250 h. p. capacity. They are operated under a head of 42 feet.

The Tacoma Light and Water Company's extensive lighting and water plants will be purchased by the city of Tacoma, Wash., as the result of the recent special election. The price paid for the entire system is $1,750,000. Chas. B. Wright, of Philadelphia, is the present owner of the company.

D. T. Denny & Sons, of Seattle, Wash., who own the Rainier Power and Railway Company, and recently acquired the properties of the Seattle Consolidated Street Railway Company, have purchased a controlling interest in the cable roads of Seattle. They now have the most extensive system of lines in the city.

The West Side Electric line, of the Portland General Electric Company, is being graded for a distance of three miles up the Willamette River, from the Oregon City suspension bridge to the mouth of the Tualatin River. The line will be extended to Portland in time. Six carloads of steel rails, weighing 56 pounds to the yard, have arrived for this line, and more are en route.

The East Side Railway Company, of Portland, Ore., has opened its standard gauge electric line, 15 miles in length, from East Portland to Oregon City. The Portland General Electric Company supplies current from its Oregon City station to Milwaukee, or about half of the distance. The remainder of the line is operated from the East Side station in Portland. An hourly service is given with 25-cent fares.

A telephone line connecting the principal towns in Clarke county, Wash., with Portland, Ore., has recently been completed by the Cape Horn Telegraph Company, of Clarke county. The line crosses the Columbia River at La Camas. A hole was cut in the rocks at the centre of the river. A fir pole 80 feet in height was cemented in place, and further supported by a pyramid of rocks 12 feet high. Tall trees on the Oregon and Washington sides act as supports at the shore ends. From the mast to the shore is one-fourth of a mile. The points thus placed in communication with Portland are La Camas, Washouga, Fisher's Landing, Vancouver, Kearns and Etna.

CANADIAN NOTES.

OTTAWA, April 29, 1893.

The New Glasgow (N. S.) Electric Light Company is now examining the water powers on the East River near Hopewell for the purpose, if feasible, of utilizing the same to drive its lighting and power plant.

Toronto.—There is a steady increase in the street railway revenue. In March, 1892, the revenue was $60,262, of which the city's share was $4,821. In March, 1893, the receipts were $55,562, of which the city's share was $5,245.

Toronto Junction.—The Finance Committee has recommended the Council to accept the offer of the City and Suburban Electric Street Railway Company for the town electric light plant. The price is $23,500, and the franchise is for 19 years.

Port Arthur, Ont.—Notice is given that the corporation of the town of Port Arthur will apply to the Legislature of Ontario for legislation to enable the town of Port Arthur to do its own municipal and electric lighting, and also to supply electric light for domestic and commercial purposes.

Montreal Island, it now seems certain, will be traversed by an electric railway in full operation by the middle of the coming summer. Messrs. Williams & Corriveau's syndicate has already made preparations to lay a double track line from the city limits to Sault au Recollet, or the Back River, a distance of 4½ miles.

Halifax, N. S.—Michael Wallace has been appointed receiver of the Halifax street railway by Chief Justice McDonald. The appointment was made on the ground that the company had failed to comply with the previous order of the court to deposit an amount mentioned as security for interest due on the company's bonds.

The Penetanguishene & Midland Electric Light and Street Railway Company is applying for a charter for the purpose of carrying on business in the towns of Penetanguishene and Midland, and in the townships of Tiny and Tay, in the county of Simcoe. The amount of the capital stock of the company is to be $100,000.

Perth, Ont.—A charter has been granted the Tay Electric Light Company, composed of Hon. John G. Haggart and John H. Balderson, of Ottawa city, and Thos. A. Code, Geo. R. McCarthy, James M. Balderson and John Wilson, of the town of Perth. The capital of the company is $30,000, and the object of the company is to supply electricity to the town of Perth.

The Canadian Parliament has just passed a bill amending the general Railway Act by the addition of a clause providing that at the crossings of railways by an electric street railway, every electric street car before crossing shall come to a dead halt, and the conductor shall go forward and see that the way is clear before signaling to the motorman to "go ahead."

Ottawa.—The Railway Committee has reported a bill giving a new company, the Automatic Telephone and Electric Company of Canada, power to construct, equip and operate telephone lines and instruments; head office, Montreal; capital, $250,000. There is a clause in the bill prohibiting amalgamation with the Bell company. There was considerable opposition to the bill, but finally it was indorsed.

The Toronto Incandescent Electric Light Company announced that after April 1 the price of electricity as an illuminant will be reduced by 40 per cent. This brings the cost of a 16 candle light from 1 cent to ⅔ of a cent per hour. The rate in Hamilton is 1 cent per hour for electric light, but a discount makes it equal to from ⅞ to ¾ cent. It is claimed that the rate is equal to the cost of gas, which is $1.50.

Montreal.—The management of the Northwest Transportation Company has decided to introduce electric lighting on its boats, and has let the contracts for that purpose. The firm of Nye & Lynch, of Hamilton, has the contract for putting in the engines. There will be one engine of the Armington & Sims pattern for each boat, which will be used to furnish power for the generator. Ahearn & Soper, of Ottawa, have the contract for the rest of the work, including also the supply of all material.

The annual meeting of the Royal Electric Company has been held. The reports showing the year's business were adopted. The gross receipts were $189,765.30, and the gross expenditure $118,937.32, leaving a balance of $70,797.98, being a fraction over 10 per cent. on the capital. There were paid out of this four quarterly dividends of two per cent. each, amounting in all to $52,092.59. A balance of $18,705.39 was carried to the credit of profit and loss account, which now stands at $267,639.31. The total assets of the company are $1,112,939 06, and the liabilities as follows: Capital $750,000; debts composed of mortgages, debentures, open accounts, etc., $795,299 75. There was spent during the year on machinery, etc., $427,000. Incandescent lights had increased from 11,000 to 28,000, but on the other hand there had been no increase in the number of arc lights throughout the city.

ENGLISH NOTES.

(From Our Own Correspondent.)

LONDON, April 12, 1893.

Municipal Lighting.—Birkenhead, which is to Liverpool what St. Paul is to Minneapolis, has decided to follow current fashions, and to erect an electric lighting central station.

Municipal Telephony.—At the last meeting of the Glasgow Town Council a special committee was appointed to consider the question of applying to the Postmaster General for a license "to supply the community with an efficient telephone service."

Submarine Telephone Cables.—Her Majesty's Telegraph ship Monarch sailed recently northward for the purpose of laying a telephone cable connecting England and Ireland. The cable is identically the same length as that laid some two years ago under the English channel from St. Margaret's Bay to Sangatte.

Telephone Poles.—The complete monopoly of the National Telephone Company, coupled with its at times overbearing demeanor, is begetting the inevitable consequence of a quiet but determined public opposition. In various parts of the country either local authorities or private individuals are placing serious obstacles in the way of the company in its pole erecting and wire running operations.

Electricity Supply in London.—At the recent meeting of the Notting Hill Electric Lighting Company, which supplies a somewhat inferior residential district, the chairman stated that his company had succeeded in elaborating a somewhat ingenious system for the purpose of extending the company's mains without incurring additional capital expenditure. The arrangement is that the customer or customers who wish for the extension should pay for it at cost price, the sum so advanced to the company being repaid in kind by a gratuitous supply of an equivalent number of Board of Trade units.

Electric Traction at Coventry.—Mr. Graff Baker, who recently took over the tramway system of Coventry, has after a lengthy and somewhat acrimonious series of negotiations with the Town Council obtained full permission to endow the inhabitants of that historic city with the blessings of the overhead trolley system. If we may judge by the correspondence published in the local papers Mr. Baker adopted a decidedly more brusque tone in dealing with the local authorities of Coventry than is customary in this country. The end, however, in these matters justifies the means, and as Mr. Graff Baker has forced the overhead trolley system upon an English town council in a remarkable short time we may hold that brusquerie is an effective weapon.

The Woodhouse-Rawson Group.—The collapse of Woodhouse and Rawson, United, is bringing in its train the collapse of its numerous financial progeny. The Elmore companies, French English, Wire, Depositing, etc., etc., are contemplating or actually going into voluntary liquidation, and the Okonite company is not exactly prospering. Whether the Epstein Accumulator Syndicate will weather the storm, and the Agmore Staveless Barrel Company float safely into port, is somewhat of a problem. The whole of the Woodhouse and Rawson group has, from the financial point of view, been in the condition analogous to Dr. Oliver Lodge's "steady strain," and now that it has been necessary to discharge, it is to be hoped that the financial position of the electrical industry will be considerably improved.

The City Lighting.—Since the City of London Electric Lighting Company has not yet got fairly to work, its revenue account does not possess any features of marked interest. The capital expenditure up to date is £150,000, leaving a balance in hand of only £30,000. Some £220,000 have been spent on buildings and machinery of all sorts, while the mains have cost about £127,000. A large item, about which we shall probably hear a good deal more yet, is that of £57,782 9s. 6d. expended on telephone conduits for the new telephone company. The city authorities are by no means pleased that the electric lighting company should have made use of the handsome privileges granted to it for making profit for other than its legitimate business, *i. e.*, by running pipes for a completely unauthorized telephone concern. It is interesting to note that the company has obtained sites for 18 transformer sub-stations, each capable of supplying 20,000 lights.

Electric Tempering.—MM. Lagrange and Paul Hoho, who for some little time past have been investigating the phenomenon of the luminous sheath which surrounds a fine wire when used as the negative electrode in an electrolyte, recently made a communication to the *Comptes Rendus* with regard to an interesting utilization of this fact. These investigators found that a piece of iron 10 centimetres long and 1 centimetre in diameter could be heated by the proper arrangement of non-conducting screens, in alternate centimetre-long sections, the heated sections fusing while the cool sections were still quite cold. So rapid was the heating that a rod of iron could be made white hot at the surface before

the interior was affected, so that by suddenly making and breaking an electric circuit, the surface of a piece of iron could be suddenly heated up and then quenched in the electrolyte. The application of this process to the tempering of springs is obvious, and one may perhaps be permitted to see in it the germs of a new method of giving a hard surface to an armor plate.

News of the Week.

THE ELECTRIC LIGHT.

Medina, O., has voted against electric lights.

Erie, Pa., is advertising for bids for lighting its streets.

Chatfield, Minn., is discussing the question of electric light.

The Calaveras (Tex.) Brick and Tile Company will install an electric light plant.

The Dundee (Ill.) Electric Light Company has increased its capital from $10,000 to $40,000.

Weymouth, Mass., has indefinitely postponed the question of a municipal electric lighting plant.

The Springville (N. Y.) Water Company has been authorized to supply the town with electric lights.

Marion, O.—The Huber Manufacturing Company will install an electric plant to furnish light and power.

Cannelton, Ind.—W. W. Taylor has been granted a six months' franchise for an electric light plant.

Batavia, N. Y., has voted for the fourth time against accepting the proposition of the electric light company.

Chester, Pa., is considering an offer of the Chester Electric Light Company for lighting the streets and the City Hall.

Nazareth, Pa.—An electric light company has been formed with a capital of $10,000 and will erect an electric light plant.

Allegheny City, Pa.—The proposed addition to the electric lighting plant, to cost $100,000, will be voted on next October.

Clyde, O., will receive sealed proposals until May 9 for apparatus, appliances, material and labor for an electric light plant.

Oakland, Cal.—In his message the mayor recommends that the city should establish an electric plant to be controlled by the Council.

Geneva, Neb.—A franchise has been granted to the Geneva Electric Light and Power Company to erect and maintain an electric lighting system.

The United States Naval Academy electric lighting plant will be in operation during the coming summer. Work is already commenced on its construction.

Williamsport, Pa., has passed the resolution of President Castnor of the Common Council to investigate the advisability of purchasing a municipal electric light plant.

Pocomoke City, Md.—The franchise of the Pocomoke City Electric Light Company and its property have been sold at auction to J. H. Merrill for about $3,500. The plant originally cost $10,000.

The Chester Light, Water and Ice Company is receiving bids on a central and electric light station, to be constructed at once at Chester, Ind. The plant will consist of one 25-light arc machine and two 500-light 2,000-volt alternators, with engines, boilers, etc. Contracts have already been signed in Chester for about 1,100 lights.

The Detroit Electric Light and Power Company, whose manager, W. H. Fitzgerald, was arrested several days ago for alleged attempted bribery of several members of the City Council, has filed a mortgage for $350,000 to the Central Trust Company of New York, covering the company's plant in Detroit. The action was authorized at a meeting of the board of directors held Feb. 13, 1892.

The Hanover Light, Heat and Power Company, Hanover, Pa., capital $25,000, has been granted a franchise and will commence work on the plant at once. The capacity of the plant will be 1,500 incandescent and 120 arc lights and a 100-h. p. generator for power purposes. The parties interested are F. E. Bailey, Philadelphia; J. W. Mumper, Dillsburg; John Gastrock, David Lonenecker and R. J. Heiges, Harrisburg.

THE ELECTRIC RAILWAY.

The McKeesport & Braddock (Pa.) Passenger Railway Company has been granted a charter to build an electric road between those two points.

The Brockton (Mass.) Street Railway Company will entirely rebuild the East Side & Whitman Street Railway, commencing within a short time.

Rome, N. Y.—J. S. Wardwell has been elected president of the Rome Street Railway Company and W. P. Rayland secretary and treasurer. The president denies the report that an immediate change to an electric system is contemplated,

Change of Motive Power.—It is stated that the C., L. & W. R. R. is considering the feasibility of running electric cars over its track from Bellaire to Martin's Ferry, Ohio. Should this be done it will probably seriously interfere with the proposed road between these two places.

The Laconia (N. H.) & Lockport Street Railway Company is making extensive improvements in its road, and will soon thoroughly reconstruct the roadbed, put in new ties and place the road in such shape that electricity may be used as a motive power whenever it is so desired.

Mr. Francis G. Daniell has resigned his position with the Evansville (Ind.) Street Railway Company and accepted one as electrical engineer with the State Street Railway Company, of New Haven, Conn., which will equip some 25 miles of road with electrical apparatus this spring.

The Bristol, Warren & Barrington Street Railway Company, of Providence, R. I., with a capital of $100,000, has applied for a franchise for an electric line to connect these towns. The Union Railroad Company has petitioned for a franchise covering practically the same territory.

The Canandaigua (N. Y.) Electric Railway Company has been granted permission to take over the property and franchise of the Canandaigua Street Railway, and will proceed at once with the work of laying rails and building the line. The power will be supplied by the local electric plant.

New Haven, Conn.—A hearing was recently given at Hartford to the petitions of E. C. Searles, for a road from North Grosvenordale to Putnam, and of R. H. Shumway, of Danielsonville, for a street railway from Putnam to Danielsonville, and of J. W. Atwood and E. P. Loft, of Danielsonville, for a street railway from that place to Jewett City. The roads will probably be operated by electricity.

The Bangkok (Siam) "Free Press" and "Times" contain descriptions of the completion of the electric railway plant which has recently been installed there by the agents of the Brush Electric Company in China and Japan. The opening of the system was entirely successful. The plant consists of McIntosh & Seymour engines, horizontal tubular boilers and Brush generators and Short motors.

The Connecticut Senate passed on April 26 the general electric railway bill by a vote of 17 to 5. An amendment requiring a majority of the directors of all street railway companies to be residents of the State prevailed. The bill places the control of all electric roads and street railways in the hands of local authorities, subject to the restrictions made by the Railroad Commissioners regarding the carrying of freight and the paralleling of steam roads.

To Use the Trolley.—The Brooklyn, Bath & West End Railroad has filed with the State Railroad Commission an application for a change of motive power, from steam to electricity, on the present line of the steam railroad, and also the spur or branch from Forty-first street and New Utrecht avenue, in New Utrecht, to Tenth avenue and Thirty-ninth street, Brooklyn, there connecting with the tracks of the South Brooklyn Railroad & Terminal Company.

The Consolidated Car Heating Company, Albany, N. Y., has issued an interesting and instructive compilation in the form of a tabular statement showing the details and totals of cost of steam and electric plants (engines of various types) necessary to generate and distribute current on a 500-volt circuit and the cost of operating its electric heaters in the different positions of the regulating switch. This table was compiled from various sources, including such authorities as Dr. Chas. E. Emery, and Crosby and Bell.

To Use Electricity.—Electricity will soon supplant horses as the motive power of the South Side Railway Company, Chicago. The employés of the Chicago City Railway Company are now completing the electrical system, and everything is in readiness for starting the cars on the day fixed. The new lines will cover 13 miles of double track. The power station is a substantial structure of brick, stone and iron, located at Fifty-second and State streets and there is room to install machinery to operate 150 miles of road. At present there are in position four 700-h. p. generators, which will be connected with four automatic cut-off engines having an endless cotton rope drive and no countershafting.

PERSONAL NOTES.

Mr. O. B. Shallenberger, of the Westinghouse Electric Manufacturing Company, was in New York several days last week giving testimony in a patent suit.

Mr. Wm. F. Breidenbach, who for some time has been with Alexander, Barney & Chapin, New York, has accepted a position with the F. P. Little Electric Construction and Supply Company, Buffalo, N. Y., and will represent this well known house on the road. Mr. Breidenbach has made many friends in the electrical trade, who will wish him every success in his new field.

The engagement of Mr. L. E. Whicher, of Boston, to Miss M. Brausen, of Cincinnati, is announced. Mr. Whicher is a director of the Beacon Vacuum Pump and Electrical Company, and has been its treasurer since its formation. He is also a member of the firm of F. A. Whicher & Co., one of the largest shoe manufacturers in the world. The couple have the best wishes of their many friends.

MISCELLANEOUS NOTES.

The California Electrical Society, San Francisco, Cal., at a recent meeting elected the following officers for the ensuing year: President, Geo. P. Lowe; vice-president, C. O. Poole; secretary, Max Caspari; treasurer, H. T. Besgor.

University of Wisconsin, Madison, Wis.—The junior class of electrical engineers recently spent a week visiting various Chicago plants, under the guidance of Prof. Jackson. This practical work is greatly appreciated by the students.

The National Electric Light Association has decided by a unanimous vote of the Executive Committee not to hold a midsummer convention. A meeting during the World's Columbian Exposition had been under discussion for some time, but this decision will probably receive the approval of the great majority of the members.

The Stanley-Kelly Motor.—In a recent communication Messrs. Stanley and Kelly, of Pittsfield, Mass., gracefully share the credit of the development of their system as follows: "In connection with the article in your issue of the 29th inst., allow us to say that throughout the development of our system we have received great aid from all our associates, and that we are indebted to them for valuable suggestions, especially so to Messrs. C. C. Chesney and W. B. Tobey."

Patent Litigation.—The Westinghouse Electric Manufacturing Company has brought suit against the General Electric Company for alleged infringement of a patent owned by it and granted to O. B. Shallenberger in 1887 (No. 373,029), relating to improvements in the construction of converters. The points specially at issue relate to the separate winding and insulation of the primary and secondary coils. The same company has also brought suit against the Stanley Electric Manufacturing Company for alleged infringement of patents relating to Tesla or rotating field motors.

Lieut. Peary, of the United States Navy, during his coming expedition to the northernmost Greenland, will record observations of the aurora upon a plan that will enable comparisons to be made in detail with records from other localities. The plan is already in operation, upon an international basis, and the results are proving to be important. Numerous observers widely distributed are desirable, and inasmuch as even those who have no special technical knowledge may make entries that will be of value; any who feel so disposed may co-operate. Further information and supplies of blanks may be obtained from M. A. Veeder, Lyons, New York, U. S. A., who will be glad to receive also any records of observations of the aurora whatever for purposes of comparison.

Industrial and Trade Notes.

The Akron Electrical and Manufacturing Company, Akron, O., has received a very complimentary letter from Hess, Synder & Co., of Massillon, O., expressing satisfaction with the Akron dynamo which has been installed in their factory.

Walker & Kepler, of Philadelphia, Pa., have just closed a contract for the installation of an electric light plant in the Women's Christian Association building, Eighteenth and Arch street, consisting of 1,100 lights and complete fixtures. Interior conduit tubes will be used.

The Eastern Forge Company's new machine shops at Portland, Me., will be designed and built by the Berlin Iron Bridge Company, of East Berlin, Conn. The building will be 57 feet in width and 150 feet in length, and will be entirely of brick and iron with all modern improvements.

The Iona Manufacturing Company, of Boston, Mass., the well known makers of electrical supplies and specialties, of which Mr. N. Marshall is manager, has just removed its factory to much larger and more commodious quarters at 336 Congress street. By this change its capacity will be considerably more than doubled, and it will be enabled to take care of all orders hereafter with promptness.

Elisha B. Seeley & Co. is the firm name of a new electric company located at 1326 Chestnut street, Philadelphia. This firm will do a general electrical contracting business. It is sole agent for the Eco Magneto Clock Company, Standard Electric Time Company, Columbian Time Recorder Company, etc. Mr. Seeley was formerly secretary of the Watchman's Time Detector Company, of New York City.

The American Electrical Manufacturing Company, 2011 and 2017 Pine street, St. Louis, Mo., of which Mr. B. Nahm is president, is one of the first in the field to manufacture incandescent lamps as a result of the recent decision of Judge Hallett. The company's advertisement states that it is now prepared for work, and has its plant in condition to fill orders promptly, and it starts out with every prospect of success.

The Nowotny Electric Company, Cincinnati, O., has now grown to such an extent that it requires three entire floors, and has now equipped its factory with the most modern and improved machinery for doing all kinds of electrical repair work, such as rebuilding dynamos and motors, making commutators for all classes of machines, etc. The company also carries a full line of electric light supplies.

Messrs. Bergtheil & Young, electrical engineers, inventors, etc., 13 Walbrook, E. C., London, England, are taking steps to secure the introduction of various American electrical specialties into the English market. Mr. Arthur Bergtheil, of the firm, is expected to arrive from London soon for the purpose of attending the Chicago Exposition and of looking up apparatus which would be of value for introduction abroad.

The New York Electrical and Development Company, 251 William street, New York City, is the correct name of the firm which manufactures the novel electric switch illustrated and described in THE ELECTRICAL WORLD of April 22, 1893. The company was there spoken of by mistake as the New York Improvement and Electrical Development Company, but the error will undoubtedly have been detected by its many friends.

The Elbridge Electrical and Manufacturing Company, Elbridge, N. Y., has issued a little circular calling attention to its improved model dynamo, which is designed for the use of teachers students and amateur investigators. With it water may be decomposed, incandescent lamps lighted, permanent magnets charged, small motors driven, and a large number of other interesting experiments performed. With a battery of from five to 15 cells this dynamo may also be used as a motor furnishing power to run light machinery. It is operated by hand power.

The F. P. Little Electric Construction and Supply Company, 135 Seneca street, Buffalo, N. Y., has issued a very attractive catalogue of the various articles which it manufactures or handles, including incandescent lamps and lamp sockets of all styles, the Kester improved arc lamps, various types of cut-outs and fuses, switches of all kinds, wire guards, reflectors and shades, insulators, line material, Habirshaw and Grimshaw wires, motors, annunciators, etc. The first 26 pages are given up to an unusually complete collection of formulæ, tables and interesting information of value to engineers and practical men.

The Gem City Manufacturing Company, Limited, Erie, Pa., is a new company just started, using the former works of the Mitchell & Brown Copper Company, with a brick building 125 × 75 feet, which it has fitted up with the necessary machinery and tools to manufacture motors, clutches, pulleys, etc. It will make fan motors a specialty at present. The officers are Thomas Brown, president; L. G. Brown, treasurer; C. K. Brown, secretary, and J. G. Moomy, electrician and general manager. Mr. Moomy was superintendent of the Taper Sleeve Pulley Works for four years, and has some valuable patents for improved pulleys.

The Rutland (Vt.) Electric Light Company, after long continued litigation with the Marble City Company, has at last secured a perpetual injunction restraining the Marble City Company from so erecting poles or stringing wires as to interfere in any manner with its poles or wires. The decree of court provides also that a master be appointed to determine the amount of damage sustained by the Rutland Electric Light Company by the Marble City Company's infringement on its rights and property. The decree has been confirmed, with order for removal of all conflicting wires and poles of the Marble City Electric Light Company, by the Supreme Court of the State of Vermont, Chief Justice James M. Tyler presiding.

The F. P. Little Electrical Construction and Supply Company, 135 Seneca street, Buffalo, N. Y., is busily engaged in equipping a factory with the latest and best types of tools and machinery for the manufacture of a general line of electric lighting and other electrical supplies, which will include arc lamps for incandescent, alternating and series work, as well as a superior type of rheostats and starting boxes for all sizes and styles of generators and motors. The company also intends to place on the market an alternating current fan motor, for which it claims high efficiency. Patents have been applied for on all these articles, which are the invention of Mr. J. F. Kester. The 110 volt lamp for direct current circuits is now ready for delivery, and the special tools and apparatus for the other articles mentioned are being gotten out as rapidly as possible. It is expected that by June 1 all the articles will be on the market.

Mr. T. J. Murphy, of 136 Liberty street, New York City, will have an attractive exhibit at the World's Fair, in the shape of a marbleized slate switchboard, 8 feet high by 10 feet wide. This board is made from Vermont electrical slate, and will be marbleized in a perfect imitation of oak wood; a shelf extending across the face of this board, and made of the same slate, will be in imitation of Mexican onyx. It is said to be one of the handsomest boards ever seen in this country. Among some of the most recent orders received by Mr. Murphy is the switchboard for the Metropolitan Club, New York, which will be made of Tennessee marble, and also a large board for the almshouse at Kings Park, L. I., to be made of Knoxville marble; also a marbleized slate switchboard for Columbia College, New York, a very fine finished board in imitation of bloodstone. Mr. Murphy is making quite a success in the mounting of switchboards complete, furnishing iron frames and erecting boards, thereby taking all responsibility until the board is in position. He is erecting another steam drill at his factory in Greenwich street, New York City, in order to secure better facilities for turning out work where drilling is required.

The Ferracute Machine Company, of Bridgeton, N. J., has recently shipped two full carloads of machinery for its exhibit at the Columbian Exposition. This machinery consists of 12 power presses, the largest weighing about 12,000 pounds; four foot presses; three spinning lathes; polishing machinery; several smaller machines for beading, trimming, threading, etc., and about 40 pairs of dies. They have secured an excellent space 30 × 25 feet, on the corner of two principal aisles and under one of the electric cranes, in Section 13, columns I J, 42 and 43, in the centre of Machinery Hall Annex, near the large engines. This will be

handsomely fitted up with a line of shafting, an engine of their own, counters, benches, an office, and with a large line of samples showing every kind of sheet-metal work. All of this machinery will be kept running with a number of operators, and several different articles will be manufactured in tin, brass, aluminium, etc., in order to show the practical working of their presses, dies, etc. The company has made a contract with the Pittsburgh Reduction Company to manufacture all the articles from thin metal which are made in sheet aluminium in the Exposition grounds. Mr. Fred. F. Smith, secretary of the company, will be in charge of the exhibit, assisted by the foreman of the press shops, Mr. Edmund Hoffman.

The Riehle Bros. Testing Machine Company, Philadelphia, Pa., is installing a very extensive and interesting exhibit at the World's Columbian Exposition, Machinery Building, Column O 25. Among other articles it will exhibit: 300,000-lb. vertical screw power testing machine with patented electric automatic screw beam; 200,000-lb. horizontal car coupler testing machine arranged for links, pins and brakebeams; 200,000-lb. vertical screw power testing machine; 100,000-lb. vertical screw power testing machine with electric automatic beam; 80,000-lb. spring testing machine; 20,000-lb. vertical screw power testing machine with vernier poise; 20,000 lb. horizontal band tester; 5,000-lb. transverse testing machine with indicator; 3,000-lb. transverse testing machine with indicator; 5,000-lb. torsional testing machine; 1,000-lb. cement testing machine with worm gear and rubber grips (the style the United States government uses); also cloth and twine testing machines. In addition to this, the company will also show its latest improved patented marble molding and countersinking machine and other articles of interest too numerous to note here in detail. This exhibit is in charge of Mr. J. R. Matlack, Jr., who is well known to the professors of the leading universities in the United States, also the officials of the railroads and the larger iron and steel works throughout the country. At the Government Building, in the government exhibit, in charge of Capt. A. H. Russell will be found a Riehle 200,000-lb. vertical screw power testing machine, and in the Quartermaster's Department in the Government Building a 200-lb. cloth testing machine. These were loaned by the Riehle Bros. Testing Machine Company to add to the government exhibit. An exhibit of the Riehle-Robie patented frictionless ball-bearing screw jacks will be found in the government exhibit, as well as in the space of Riehle Bros. Testing Machine Company.

Business Notices.

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Oil Filters for sale cheap. Prices on application to Purity Oil Filter Manufacturing Company, 901 Water street, Pittsburgh, Pa.

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OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

UNITED STATES PATENTS ISSUED APRIL 25, 1893.

[In Charge of W. A. Rosenbaum, 177 Times Bldg., N. Y.]

495,996. Closed Conduit Electric Railway; William P. Patton, New York, N. Y. Application filed July 15, 1892. In an electric railway, the combination with an insulating longitudinally grooved timber or block on a railroad bed, and an elongated electrical conductor thereon, of a bottom channeled spring supported transmitter rail, and laterally projecting lugs on the transmitter rail which loosely engage vertically elongated holes in side pieces of the insulating block.

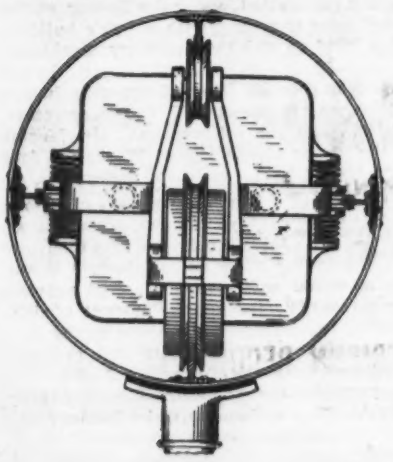
496,019. Electric Soldering; Elihu Thomson, Lynn, Mass. Application filed Jan. 22 1889. An improvement in uniting thin metal plates by a heating electric current passed through the metal and cementing material between the pieces to be united consisting in clamping the pieces between two electrodes, passing electric current from one to the other, and maintaining the clamping pressure upon the pieces after the heating current is withdrawn and until the joint is cold.

496,020. System of Electric Distribution; Elihu Thomson, Swampscott, Mass. Application filed Dec. 29, 1890. The combination, with a series multiple arc system, of a continuous current energy transformer connected to main and middle intermediate wires, and provided with a compounding or regulating field magnet coil. (See illustration.)

496,041. Electro-Mechanical Block-Signaling Apparatus; Murray Corrington, New York. Application filed April 26, 1892. The combination of a visual train-signal; a hand lever for shifting same into either of two positions, a lock for retaining the lever and signal in position to indicate "clear," and a mechanism mechanically actuated by the impact of a moving train for releasing the lock as the train enters the block guarded by the signal.

496,067. Electric Alarm for Tanks; F. C. Skelton, Montreal, Can. Application filed Oct. 4, 1892. The combination in an electric alarm for indicating the level of a liquid in a tank or other vessel, of adjusting nuts on a cord, bar or stiff upright, passing through apertures in the overlapping terminals of an open alarm circuit, the bar or stiff upright being moved by a float on the surface of the liquid.

496,076. Signaling Apparatus; Hermann Wetzer, Pfronten Germany. Application filed Aug. 8, 1892. In a signaling device a pendulum, adapted to receive its oscillating impulses from the calling-up station in combination with a stop and means for releasing the stop from this calling-up station to arrest the pendulum, when no signal is given.



No. 496,329.—Telpher System.

496,081. Insulator; Joseph F. Wright, Colorado Springs, Colo. Application filed Jan. 31, 1893. The combination of a non-conducting tube or holder and a thumb screw having a non-conducting button on its lower end operating therewith.

496,103. Electric Cigar Lighter; Lawrence T. Smith, Barrington, R. I. Application filed Oct. 24, 1892. A cigar lighter adapted for continuous heating by electricity, consisting of a non-exposed conducting wire or filament of high resistance mounted in a plug or cylinder of fire resisting material, having the plug removably secured to conducting arms or holders mounted in a head located in an electric circuit.

496,126. Storage Battery; F. A. La Roche, Philadelphia, Pa. Application filed March 25, 1892. A cell, electrodes and battery liquid in combination with an interior cell containing one of the electrodes, and inclosing it above the liquid and impervious to the gases generated in the battery at the parts above the liquid.

496,134. Electric Synchronizer for Clocks; H. S. Prentiss, Elizabeth, N. J. Application filed May 21, 1892. A time piece provided with a self-contained detent actuated from the train of another time piece, to engage with the train and arrest the motion at the hour as indicated by the time piece, and an electro-magnet arranged to act on the detent for effecting the release of the train at the exact hour.

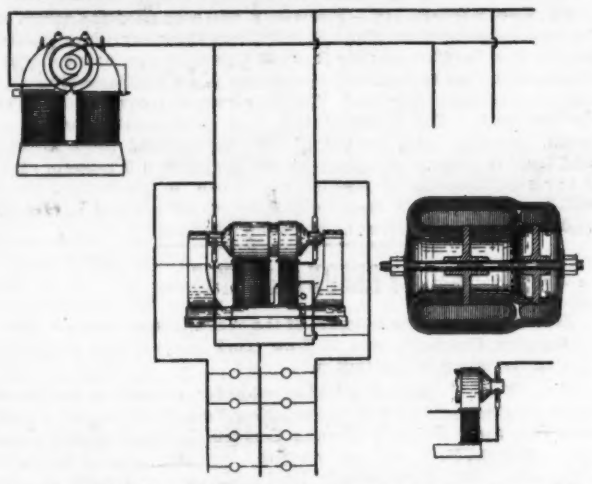
496,135. Electric Synchronizer for Clocks; H. S. Prentiss, Elizabeth, N. J. Application filed June 22, 1892. A time piece provided with a connection between its pendulum and pallet lever, a device electrically actuated to break the connection at the hour indicated by the time piece.

496,137. Mechanical Telephone; Geo. H. E. Ricke, Cincinnati, O. Application filed April 15, 1891. The combination of a box formed in two parts suitably secured together, a sounding membrane and an adjustable secondary membrane held stationary adjacent the sounding membrane.

496,192. Annunciator; J. H. Elfering, Milford, Conn. Application filed Oct. 3, 1892. The combination with a frame of a vertically movable rack mounted therein and projecting above and below same, a want-tablet attached to the projecting upper and lower ends of the rack and displaying several wants arranged one above the other, a magnet mounted in this frame, a double acting pawl hung in the frame with its ends respectively arranged to co-operate with the magnet and pawl, and a spring connected with the pawl and tending to move it away from the rack against the pull of the magnet.

496,207. Electric Reporter; Major Dane Porter, Brooklyn, N. Y. Application filed Nov. 27, 1886. The combination with a number of reporters, of a receiver having a terminal of each reporter, the terminals being grouped in blocks respectively located in branches of the main line, the receiver being also provided with block indicators located in the branches and with a hand lever for restoring such indicators to their normal positions.

496,208. Process of and Apparatus for Tempering or Hardening Steel Wire; Henry E. Procunier, Oak Park, Ill. Application filed May 4, 1891. A vertical muffle through which the wire is drawn, means for heating and moving the wire in combination with a chilling bath and a supply pipe delivering the chilling fluid to the bottom of the bath.

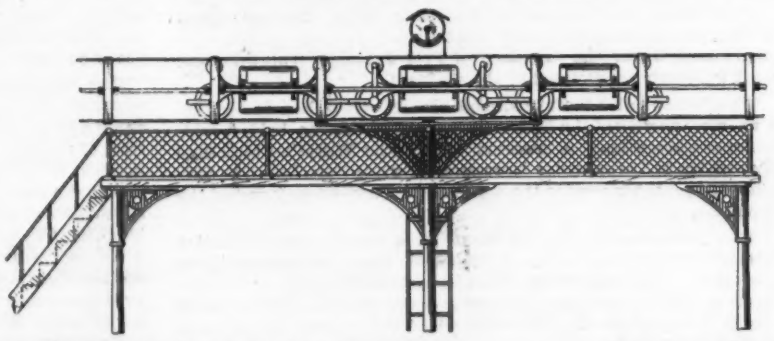


No. 496,020.—System of Electric Distribution.

496,212. Electric Converter; William Stanley, Jr., Great Barrington, Mass. Application filed Oct. 1, 1887. An electric converter consisting of insulated laminæ of soft iron, annular in form, having inner and outer teeth, coils wound between the teeth and a soft iron cylindrical core closing the teeth about the coils. (See illustration.)

496,224. Diaphragm Holder for Telephones; Silas W. Holman, Boston, Mass. Application filed Nov. 5, 1892. In a magneto telephone instrument a plate diaphragm, a pair of opposed rings of different diameters which hold the diaphragm under tension in one direction by its tangential contact with each, and a magnet which holds the diaphragm under tension in the opposite direction. (See illustration.)

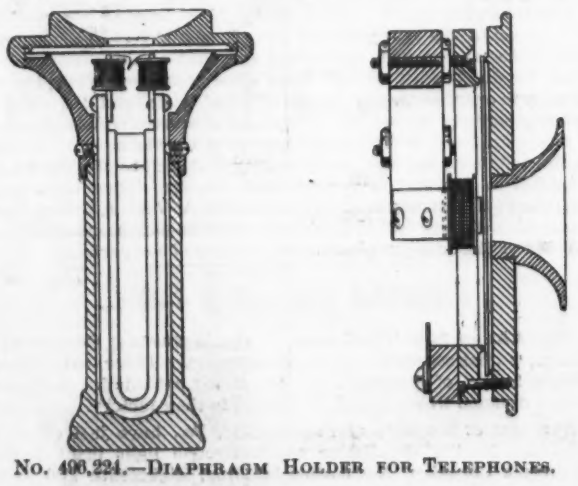
496,228. Dry Battery; Hugo Koller, Vienna, Austria-Hungary. Application filed June 21, 1892. Plates for dry cells composed of agar-agar mixed with a metallic salt.



No. 496,329.—Telpher System.

496,244. Electro-Galvanic Adhesive Plaster; Frederick A. Barret, St. Louis, Mo. Application filed Sept. 28, 1892. In an electro-galvanic adhesive plaster, the combination with a battery and electrodes of means for electrically connecting or disconnecting a portion of said electrodes.

496,280. Electric Railway Trolley; Wesley W. Pritchett, Ogden, Utah Territory. Application filed Nov. 2, 1892. The combination with a car of a tilting rock plate pivoted on the car top, oppositely extending trolley poles carried by the rock plate, and having trolleys at their ends to engage a wire, and mechanism for holding either of said trolleys in engagement with the wire.



No. 496,224.—Diaphragm Holder for Telephones.

496,307. Combined Dynamo Electric Machine and Water Motor; John O. Heinze, Jr., Lynn, Mass. Application filed Oct. 15, 1892. In combination, an intermittently actuated water motor, and electric generator operated directly thereby, a commutator for the armature, a waterproof metallic casing inclosing the motor and generator and supporting the bearings thereof, and a detachable part carrying the commutator brushes and circuit connections.

496,308. Cut-Out and Circuit Protector; John O. Heinze, Jr., Lynn, Mass. Application filed Oct. 15, 1892. A fusible cut-out for electric circuits, comprising circuit terminals, a fuse wire spanning said terminals, and sustained by refractory insulating material; a movable block of refractory material normally sustained by the fuse and adapted when released by the destruction of the fuse to substantially close the space previously spanned by the fuse and thereby increase the distance to be traversed by an arc between the terminals.

496,309. Voltmeter and Ampere Meter; John O. Heinze, Jr., Lynn, Mass. Application filed Oct. 17, 1892. A volt and ampère meter comprising a stationary solenoid and connections therefrom to receive the current to be measured, a layer of copper on each end of the solenoid, an iron envelope or band inclosing the solenoid and having its central portion reducing in thickness to the axis of the solenoid, a segmental iron armature eccentrically journaled within the solenoid and free to swing toward and away from the margins of the tapering depressions in the enveloping iron, a counterbalance spring, and an indicating device connected with and actuated by the armature.

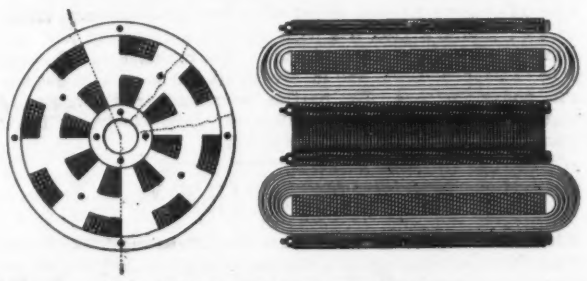
496,312. Electric Measuring Instrument; Rudolph M. Hunter, Philadelphia, Pa. Application filed April 26, 1893. In a measuring instrument for electric currents, the combination of a pivoted pointer, an expansion wire adapted to operate the pointer, a spring acting to hold the end of the expansion most distant from the pointer against movement, a tension wire adapted to hold the spring against movement except under changes of temperature, and electrical circuits for supplying current to the expansion wire without traversing the tension wire.

496,329. Telpher System; C. J. Van Depoele, Lynn, Mass. Application filed May 15, 1891. In an electric railway, a suitable track having upper and lower and side rails, a series of concentric rings surrounding the rails, the upper and lower rails being secured to a block of insulating material, the latter secured to the rings, and contact wheels running on the rails. (See illustration.)

496,330. Electric Locomotive; C. J. Van Depoele, Lynn, Mass. Application filed Sept. 24, 1891. An axle, an electric motor vertically spring supported at one end on the axle, a resilient support for the opposite end of the motor, driving pinions upon the armature shaft, a flexible connection rotatively mounted with respect to the axle, a part fixed to the axle and engaging the flexible connection, and intermediate gear between the armature shaft and the rotatively mounted flexible connection.

496,331. Electro-Magnetic Reciprocating Pump; C. J. Van Depoele, Lynn, Mass. Application filed Dec. 12, 1891. An engine comprising motor coils, a magnetic plunger adapted to be reciprocated therethrough, a pump actuated by the plunger, and passages extending from the pump and through the electric engine, and in proximity to the motor coils.

496,366. Electric Light Display System; Daniel McFarlan and Charles Mattathias Jacobs, New York. Application filed, Nov. 22, 1892. The combination of a signboard at a given point of given size, carrying a given number of electric lamps equally spaced in parallel rows equally spaced, an operating board at a distant point and of smaller size, carrying the same number of circuit closers equally spaced in parallel rows equally spaced, the



No. 496,212.—Electric Converter.

circuit closers being in circuit with the respective lamps in such a manner that any given lamp in any given row is in circuit with the corresponding circuit closer, means for illuminating the operating board at the points of location of the circuit closers, composed of a lighted lamp attached to the circuit closers and normally closing the holes in the operating board.

496,371. Electric Meter; Francis Teague, London, England. Application filed Feb. 2, 1892. In an electric meter, a cylindrical electro-magnet case having internal poles and a closed bottom, one of the poles being annular in form and dependent from the top of the case and forming a core for a shunt winding.

496,381. Cable Rack; A. C. Gray, Pittsburgh, Pa. Application filed Oct. 22, 1888. A cable rack with upright rods or tubes between horizontal cross-pieces, bracket arms journaled on the upright rods, a set screw passing through the bracket arm provided at the journal end with a thread adapted to fit an internal thread on the bracket arm, the screw being provided with a head or knob whereby when cables are supported on these bracket arms the same may be adjustable from the ends without removing the cables.

496,382. Controlling Device for Electric Elevators; Chas. E. Moore, Boston, Mass. Application filed June 21, 1892. The combination with an operating rope wheel, shaft, cam, weighted lever, rheostat, having a brush arm connected with the weighted lever, a pinion, spindle, brush arm, the weighted wheel turning loosely on the shaft, a ratchet wheel secured to the shaft, a pawl, wheel and rack secured to the lever adapted to engage the pinions.

496,386. Electric Arc Lamp; Wm. H. Akester, London, England. Application filed Sept. 9, 1892. This device consists of a shaft, a wheel mounted loosely on it, a spring or something similar for normally retaining the shaft in a given position, a screw thread on the shaft, a nut loosely engaging the wheel, and means for causing the carbons to rise and fall by the rotation of the wheel, a solenoid and suitable connections from the core of the solenoid to the nut for casing same to partially revolve with the rise and fall thereof.

496,387. Electric Arc Lamp; Wm. H. Akester, London, England. Application filed Sept. 9 1892. In an electric arc lamp, a regulating device consisting of a vertically movable box or case filled with spherical pellets and held in normal position by a spring or weight, a rod passing therethrough and connected with one of the carbons, an apertured disc located in the box and a stud or projection bearing on the disc and carried by some electrically controlled part of the lamp.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886 - can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.

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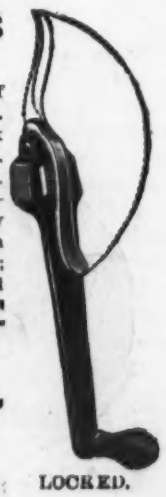

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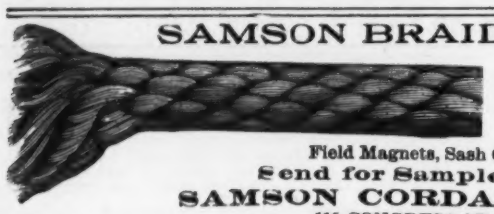

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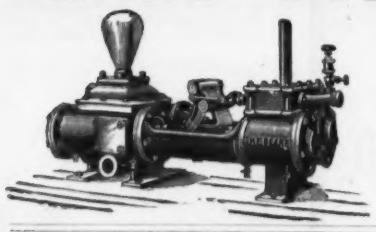

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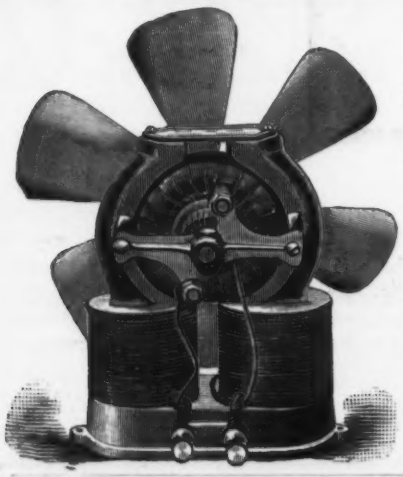

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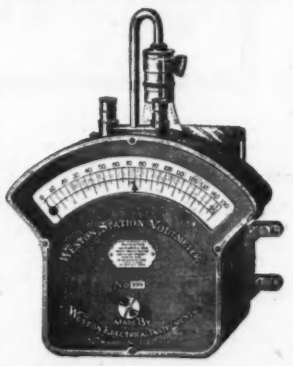

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